U.S. EPA Coalbed Methane Outreach Program

# China's Energy Markets: Anhui, Chongqing, Henan, and Guizhou Provinces

U.S. Environmental Protection Agency
November 2011

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## Acknowledgements

This publication was developed at the request of the United States Environmental Protection Agency. Through the Coalbed Methane Outreach Program, Raven Ridge Resources, Incorporated team members: Raymond C. Pilcher, James S. Marshall, Charlee A. Boger, and Martin Weil authored this report based on feasibility studies performed by Raven Ridge Resources, Incorporated and Advanced Resources International.

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## Acronyms and Abbreviations

| | |
|---|---|
| CBM | Coalbed Methane |
| CDC | China Datong Corporation |
| CDM | Clean Development Mechanism |
| CMM | Coal Mine Methane |
| CNG | Compressed Natural Gas |
| CNOOC | China National Offshore Oil Corporation |
| $CO_2e$ | Carbon Dioxide ($CO_2$) Equivalent |
| CPIC | China Power Investment Corp |
| CQEIG | Chongqing Energy Investment Group |
| CSPGC | China Southern Power Grid Company |
| ECPG | East China Power Grid |
| FGD | Flue Gas Desulfurization |
| GMI | Global Methane Initiative |
| kcal | Kilocalorie |
| GW | Gigawatt |
| HIG | Henan Investment Group |
| kg | Kilogram |
| kj | Kilojoule |
| km | Kilometers |
| kv | Kilovolt |
| kWh | Kilowatt Hour |
| LNG | Liquefied Natural Gas |
| LPG | Liquefied Petroleum Gas |
| m | Meters |
| M2M | Methane to Markets |
| $m^3$ | Cubic meters |
| mm | Millimeters |
| mmbtu | Million British Thermal Units |
| mmkWh | Million kilowatt hours |
| MPa | Megapascal |

| | |
|---|---|
| MW | Megawatt |
| MWh | Megawatt hours |
| N/A | Not applicable |
| NDRC | China National Development and Reform Commission |
| RMB | Renminbi, Chinese currency |
| SCEC | Songzao Coal and Electricity Company |
| SERC | State Electricity Regulatory Commission |
| SPC | State Power Corporation |
| t | Metric tons |
| TWh | TeraWatt Hour(s) |
| UHV | Ultra High Voltage |
| USD | United States Dollars |
| USEPA | United States Environmental Protection Agency |
| VAM | Ventilation Air Methane |

# 1. Executive Summary

This document reports the results of energy market analysis performed during the course of several comprehensive coal mine methane (CMM) recovery and utilization feasibility studies conducted in China. These studies were conducted as a part of a larger initiative funded by the United States Environmental Protection Agency (USEPA) under the Global Methane Initiative (GMI), formerly the Methane to Markets Partnership (M2M). USEPA's Coalbed Methane Outreach Program (CMOP) has launched five full-scale feasibility studies of coal mine methane recovery and utilization projects at Chinese coal mines. The information in this study comes from three completed feasibility studies: Feasibility Study of CMM Utilization for Songzao Coal and Electricity Company Coal Mines (May 2009), Feasibility Study for CMM Drainage and Utilization at Liuzhuang Coal Mine, Huainan Coal Field (February 2010), and Feasibility Study of CMM Utilization for Guizhou Nengfa Power Fuel Development Co., Ltd. Linhua Mine Located in Guizhou Province (December 2010), as well as the soon to be completed Feasibility of Improved Coal Mine Methane Drainage and Use at the Mines of the Hebi Coal Industry (Group) Corporation, Limited. The completed and published studies can be found at http://epa.gov/cmop/international/china.html.

Note that these reports, specifically the report for Songzao Coal and Electricity Company Coal Mines, which covers the energy markets of Chongqing, was written in 2008 and 2009 and data and market conditions have changed. For example, this document reports that the electricity market in Chongqing is expected to be soft for some time; however, it is known that this market has recently become more robust. Energy markets in China are dynamic, reflecting the country's generally growing economy.

China's energy economy is dominated by coal as coal has consistently accounted for 65-70 percent of China's primary energy in recent years. **Figure 1** shows China's energy sources as of 2007.

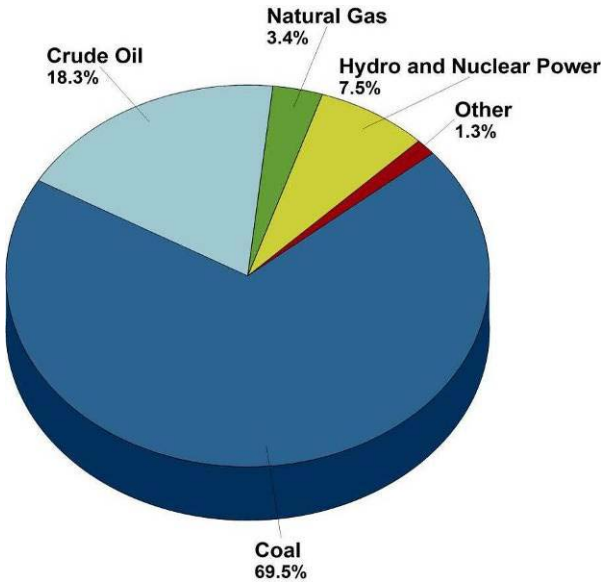



**FIGURE 1: CHINA'S PRIMARY ENERGY SOURCES, 2007**

Domestic coal production has strained to keep pace with rapidly growing demand in recent years. Although output overall grew by the same 10 percent per year as consumption between 2000-2007, the

most rapid growth took place in 2003-2005, the years immediately following the government's decision to largely free coal prices.

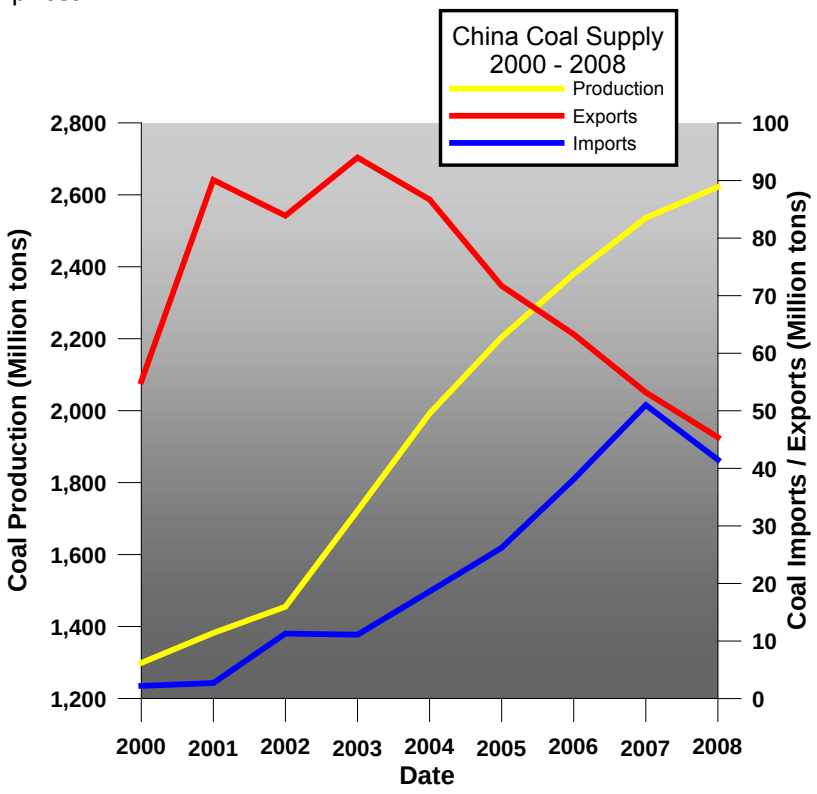



**FIGURE 2: CHINA'S RAW COAL SUPPLY**

Coal exports, which had expanded steadily from the mid 1990s through 2003, declined by over 50 percent between 2004 and 2008. Thermal power generation, which grew at a nearly 15 percent rate through 2004-2007, was the principal driver for coal industry expansion. In 2007, power plants consumed approximately 1.4 billion tonnes of coal, or 55 percent of the total.

As the economy, and in particular major coal consuming industries such as electric power and steel, grew at 13-15 percent rates and a sellers' market psychology took hold, coal prices increased dramatically in 2007 and the first half of 2008. The sudden upsurge in steam coal prices created particular problems for power plants, whose ability to absorb the increases were limited by central government controls on the prices the plants could charge to the grid for their output. The Chinese economic slowdown of fourth quarter 2008, and declines in production of thermal power and steel during the quarter reduced coal demand and dramatically changed the dynamics of the coal market in China. It would be logical to expect that a price drop will facilitate the central government's efforts to close down the least productive and most dangerous of the locally controlled small mines. However, the recent upswing in international coal prices has caused China to reduce imports and offset the deficit in supply with local production; the impact on mine closures is unknown.

Historically, the difficulties of transporting coal over the mountains from the north have forced Chongqing to rely primarily on its own coal production, despite the difficult mining conditions and the mediocre quality (high sulfur content in particular) of the Chongqing deposits. Coal production has climbed steadily with consumption in recent years.

Coal produced in Guizhou is used primarily to supply coal fired power plants within the province. A portion of the output of these plants is sold into the Guizhou Provincial grid, and a portion is transmitted through China Southern Power Grid 500 kilovolt transmissions lines for sale into coastal Guangdong Province under the "West to East"[1] electricity program sponsored by the central government. Based on the characteristics of both the coal and the electric power markets in Guizhou, there is no realistic risk of a downturn in demand for coal output.

China's electricity market has been on the rise with rapid construction of electricity generation capacity since 2003. There is a distinct possibility that power generation capacity will outstrip demand in many parts of the country over the next 3-5 years. The appetite for new power construction will likely decrease correspondingly, and dispatch of existing plants – particularly coal-fired power plants – will decrease. Civil and commercial consumption of power will certainly grow rapidly as urbanization accelerates – but as these sectors only account at present for approximately 14 percent of total electricity consumption, they cannot be expected to completely substitute for slower growth in an electricity-intensive industry. The Chinese government itself hopes to use the downturn of 2008 to recalibrate growth along a more sustainable, less energy-intensive path, and it is conceivable that the least energy efficient steel, cement plants, etc. will be shut down during the immediate period of slower growth.

Patterns of growth changed abruptly under the impact of the global economic slowdown in the second half of 2008, carrying through into the first half of 2009 (**Figure 3**).

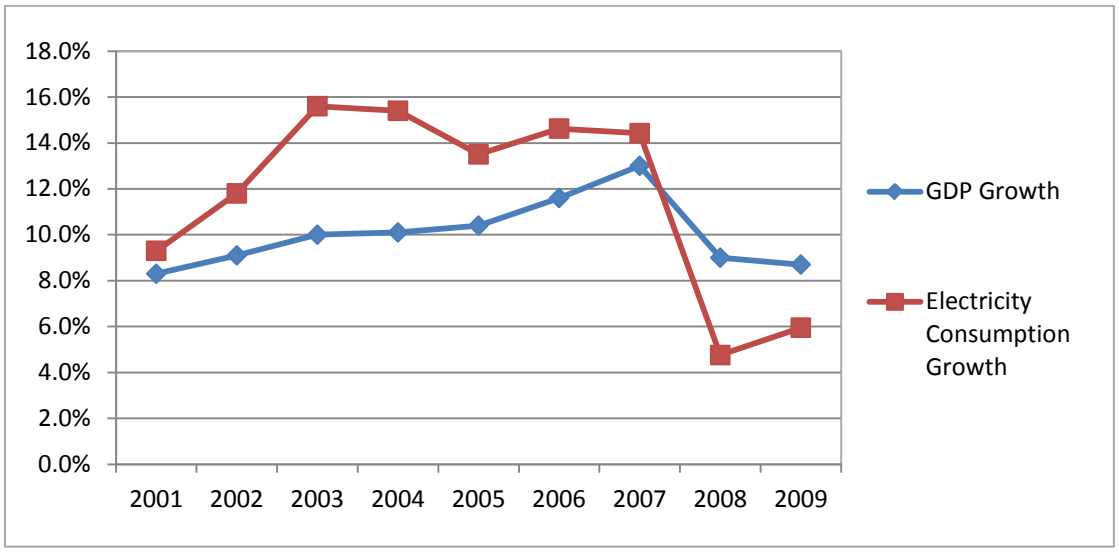



**FIGURE 3: CHINA: ECONOMIC GROWTH AND ELECTRICITY CONSUMPTION GROWTH, 2000-2009. SOURCES: CESY 2008 TABLES 1-1 AND 5-13, NBSC 2009, NBSC 2010, NDRC 2010.1**

[1] "West to East" is a term commonly used in China to refer to a specific series of projects. "West to East" is a term with political resonance used to convey the Chinese government's commitment to accelerate economic development in the poorer western provinces and to better integrate them with the more developed eastern coastal areas. It is an unofficial Chinese name for a number of infrastructure projects. "West to East" electricity projects involve the construction of thermal and hydro power plants in Guizhou, Guangxi and Yunnan Provinces and high-voltage transmission lines to connect them to load centers in Guangdong over the past 10 years.

China has long struggled with the problem of most of its power generation facilities, both coal fired and hydroelectric, being located in the north and west of the country, while greater than 75 percent of energy demand comes from the heavily industrialized and densely populated central and eastern regions. A lack of reliable transmission capability has led to frequent supply disruptions in the major energy consuming regions.

A state monopoly, the State Power Corporation (SPC), ran all sectors of China's national electricity system until 2002, when it was dismantled by the government and several new companies were created to run the generation sector and the transmission and distribution sector as separate entities. While some market competition has been allowed in the generation sector, the transmission and distribution networks continue to be heavily state-controlled, with the government providing blueprints for the development of the national electricity grid for the next ten years.

China's electricity prices are complex and still mostly regulated by the government. There are three general price categories: the wholesale price, the transmission and distribution price, and the retail price. The wholesale and transmission/distribution prices are approved by China's National Development and Reform Council (NDRC), and the retail price is set by the NDRC. The NDRC determines both the price at which generating companies can sell power to the grid and what prices the grid operators can charge different categories of users. These prices are set on a province by province basis, in consultation with local price bureaus. The NDRC attempts to balance affordable prices for industrial and residential customers with the need for generation and grid companies to make enough profit to finance future power plants and transmission networks. Electricity rates currently favor industrial customers and can be 40 percent lower than other retail customers (EIA, 2009). China's electricity market is complicated by the government trying to control prices to end users, while the price of coal, the major fuel source for power generation, is subject to market forces.

In 2007, in a bid to accelerate the development of power projects fueled by CMM, NDRC issued new requirements covering the generation of electricity by CMM/CBM projects (IEA, 2009). Specifically, CMM generated electricity is to be given priority by grid operators, who should purchase the electricity at an NDRC specified, subsidized price. In practice, electricity distribution companies do not find it profitable to use the more expensive, subsidized CMM generated power, and have tried to make up lost revenue by charging additional fees for use of the power distribution grid. This in turn makes the economics of CMM electricity generation for sale to the grid unattractive for mine operators. Despite this, power generation from CMM is becoming increasingly important in China. CMM-generated power capacity more than doubled from 2005 to 2006 (IEA, 2009).

Anhui is an interior, more rural province whose economy modernized more slowly. As it is also by far the largest coal producer in the East China region, regional and national planning authorities developed the so-called "Anhui power to the East" program in the mid 2000s with the explicit goal of transforming Anhui into a power supplier to the Yangtze Delta provinces of Zhejiang, Shanghai, and Jiangsu. Anhui increased its power generation capacity by nearly 150% from 2006-2010 to 29,300 MW with the addition of 17,200 MW of coal-fired power capacity. During the first half of 2011, Zhejiang and Jiangsu Province electricity consumption rose by 11.7 and 13.6 percent, respectively. If this trend continues, the gap between electricity production and consumption in these provinces will increase rapidly, and Anhui will continue to be able to sell as much power into the Delta provinces as it can spare. In Anhui itself,

the electricity market is most developed in cities such as Huainan with a population of approximately 1 million and a wide range of industrial and manufacturing operations. Currently, most CMM projects in Anhui are power generation or town gas projects.

The Chongqing electrical distribution system is dominated by the Chongqing Power Company, a subsidiary of the Central China Grid Company which accounts for about 78 percent of total supply, with the remainder coming from small regional grids and self-owned power plants of industrial enterprises. Electricity consumption in Chongqing grew steadily, by 13.3 percent per year from 2004 – 2007; however, the decline in industrial production resulting from domestic real-estate investment slowdown and the international financial crisis has depressed electricity consumption, with year-on-year electricity growth dropping in late 2008. Due to the Central China Grid's policy to dispatch hydropower whenever possible, many thermal power plants are operating below capacity. It appears that, barring the rapid resumption of the industrial growth patterns of the 2003-2007 period, the market for thermal power in Chongqing will be soft for some time to come. This leaves little incentive for the Chongqing grid to buy power from proposed new plants burning CMM.

Henan province is the sixth largest provincial consumer of electricity in China. As well as consuming significant amounts of electricity, Henan province is also a large producer of electricity, with more than a dozen power plants constructed close to a major provincial city. Hebi City, with a population of over 1 million and home to a wide range of industrial and manufacturing companies, purchased 2.5 billion kWh of electricity in 2008 from the national grid. Hebi also receives electricity from a 2,200 MW thermal power plant located in the city. Large electricity consumers include magnesium metal producers and cement product manufacturers, such as the Tongli Cement Company which used 170 million kWh in 2007. Electricity demand in the Hebi area is expected to increase in line with national projections, at rates between 5 to 10 percent per year.

The Guizhou power grid is one of five interconnected provincial grids which are controlled by the state-owned China Southern Power Grid Company (CSPGC). Although Guizhou is one of China's smallest, poorest, and least urbanized provinces, its interconnections with the rest of the country have grown stronger in recent years, and its economic growth has closely tracked that of China as a whole. The province's disproportionate economic dependence on energy-intensive extraction and manufacture of commodities such as coal, chemical fertilizers and their inputs/associated products, and aluminum, however, creates the potential for some volatility in electricity demand. Coal mine methane is among the more promising source of new, lower carbon energy sources in Guizhou Province. Most of the 138 million metric tons of coal mined in Guizhou during 2009 came from mines with high methane concentration that pose a considerable safety risk.

Only four percent of China's energy is provided by natural gas. Being considerably cheaper to produce than natural gas, coal will remain the dominant power source into the future, but the Chinese government is looking increasingly to mitigate the health and environmental problems associated with pollution from coal burning (especially in cities) by actively promoting the use of cleaner energy options, such as natural gas and coal mine methane. The government plans to increase the share of natural gas as part of total national energy consumption to ten percent by 2020.

The Chinese central government's decision at the turn of the twenty-first century to develop long-distance pipelines to transmit gas from rich fields in remote areas of Northwest and North-Central China

to the eastern heartland and to introduce imported LNG into the southern coastal areas has sparked an historic boom in China's natural gas consumption which was unaffected by the economic turbulence of 2008-2009 and appears poised to continue for the foreseeable future. Even this impressive growth only brought the natural gas proportion of China's primary energy supply to 4-5 percent, compared to 23-24 percent in Europe and the USA.

Natural gas consumption in China is driven primarily by the chemical/fertilizer raw material industry, residential and commercial use, as well as industrial use. Secondary consumers are electric power generation, automotive, and cement manufacture. China's natural gas consumption by sector is shown in **Figure 4** below.

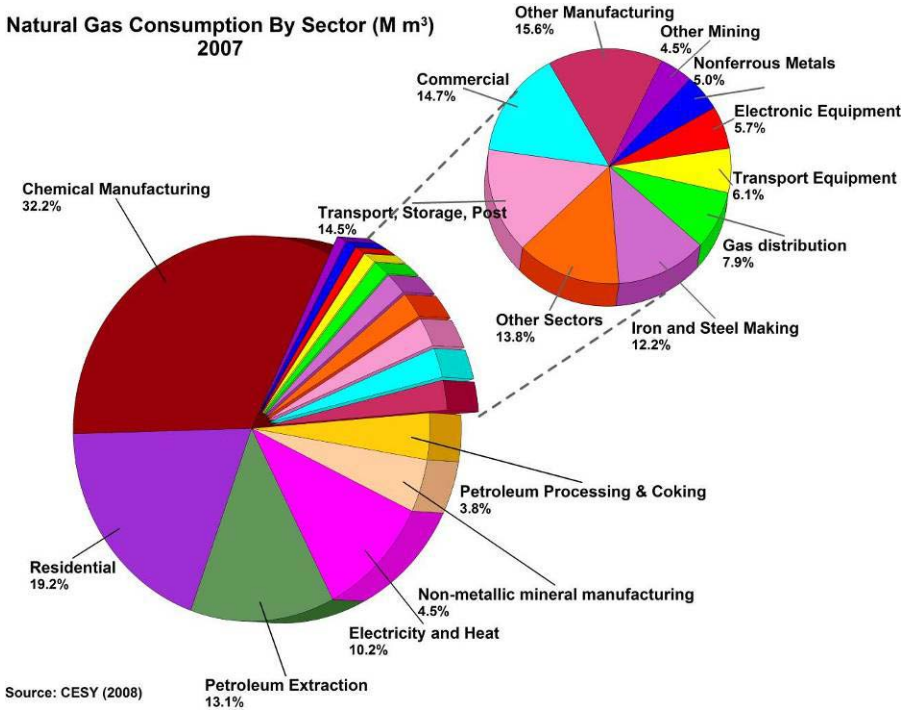



**FIGURE 4: CHINA'S NATURAL GAS CONSUMPTION BY SECTOR, 2007**

CBM and CMM are gradually emerging as a complementary natural gas resource. Approximately one billion cubic meters of over 90 percent methane concentration CBM were recovered nationally in 2009 from surface wells drilled either by coal mines or other concession holders, almost entirely from the Qinshui Basin near Jincheng in Southeast Shanxi Province.

The vast majority of China's liberated CMM is emitted to the atmosphere as low-concentration ventilation air methane (VAM); however, recovery of between 10 to 50 percent concentration CMM by drainage in association with mining doubled between 2006 and 2009, with usage rising to almost two billion cubic meters. Most CMM is consumed in the immediate coal mining areas either in small distributed power stations or as household, commercial or industrial fuel, with a small number of mines with high recovery volumes having developed central station power plants or industrial facilities to burn CMM.

Cryogenic technologies to purify and liquefy medium-methane content CMM that are already proven outside of China, offer the potential to integrate CMM into the national natural gas market. Chinese domestic companies are also developing the technology. A 100 million cubic meter plant is in the advanced planning phase at the Songzao Coal and Electricity Company in Chongqing Municipality.

Now that government policy actively encourages residential use of natural gas and significant numbers of urban residents are finally experiencing the environmental benefits and the convenience of natural gas relative to competing household fuels, such as liquefied petroleum gas, coal gas, and coal, demand for residential natural gas use is rising rapidly. Local governments in all areas of the country are scrambling to obtain access to natural gas, and private as well as publicly owned natural gas distribution networks are sprouting up in cities all over the country.

Of the estimated 577 million people living in Chinese cities, suburbs, and towns, only 102 million had access to natural gas at year-end 2005. **Figure 5** shows China's access to natural gas and natural gas consumption by province.

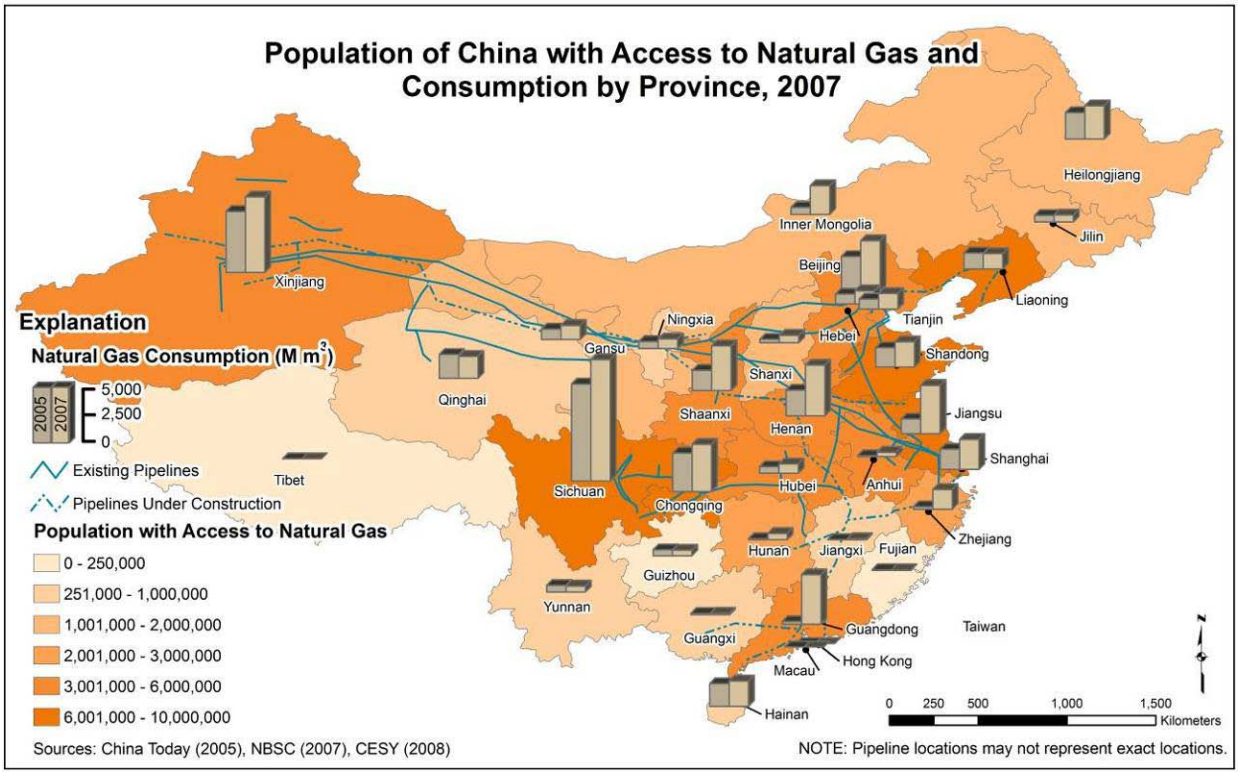



**FIGURE 5: POPULATION OF CHINA WITH ACCESS TO NATURAL GAS AND CONSUMPTION BY PROVINCE, 2007**

The key to the expansion in natural gas consumption over the past decade has been the decision of the Chinese central government to aggressively develop gasfields in remote areas of the western part of China and, for the first time in the country's history, to build long-distance pipelines to connect these sources (as well as the existing Sichuan gasfields) to major population and industrial centers in the eastern part of the country. The central government has acted through the two land-based, state-owned oil and gas producers China National Petroleum and Natural Gas Corporation (PetroChina) and

China National Petrochemical Corporation (Sinopec) and the state-owned banking system. As a direct result, some of China's largest cities, including Beijing, Shanghai, Nanjing, Wuhan, Changsha, Xian, and Lanzhou as well as numerous smaller and medium sized cities in the surrounding provinces are burning natural gas for the first time.

Two major pipeline projects are underway – the Second West to East gas pipeline[2] which is expected to achieve full capacity in 2012, and the Burma-China Gas Pipeline with gas projected to start flowing to China in 2012-2013. The new pipelines will extend the national network into virtually all provinces of China. But there will likely remain small-medium sized cities within these provinces that will not be tied into the local distribution grids, and many of the larger cities will not receive sufficient gas to fully cover their residential populations.

Although some price rationalization has occurred in recent years, the Chinese government still controls the price of natural gas in most markets. China has been raising gas prices rapidly since LNG imports began in 2006 and is expected to continue increasing gas prices. However, domestic gas prices remain significantly lower than international prices. Delivered gas prices can vary significantly across China's diverse gas fields, depending both on geography as well as the type of end user and its ability to pay.

Coalbed methane prices are theoretically not subject to NDRC regulation and can be negotiated between the buyers and sellers. But when CBM is supplied through long distance transmission pipelines, the regulated (lower) natural price in the same areas is normally used as the reference for negotiating and determining the CBM price.

China's government has implemented a number of policies related to CMM. In April of 2007, China's NDRC issued *Notice on CBM/CMM Price Management* to increase CMM output by addressing market barriers. The notice states that the price of gas that is not distributed via city pipeline networks can be determined freely through negotiations. The price of gas distributed via city pipeline networks and operations under government control are to be determined according to the heating value of the gas as compared to substitute fuels such as natural gas, coal gas and liquefied gas.

NDRC also issued the *Notice on Executing Opinions on Generating Electricity with CBM/CMM* which encourages the deployment of power generation projects with CBM/CMM. The notice requires that electricity generated by CBM/CMM power plants is given priority by grid operators who purchase surplus electricity at a subsidized price. CBM/CMM power plant owners are also exempted from market price competition and do not undertake any responsibilities for grid stability. In practice, however, grid operators have not been willing to purchase power generated by CMM power plants. This notice has not been observed in practice, however.

Despite the pro-CMM policies, there are conflicting regulations regarding methane concentration. The rules governing the permitted concentration of methane in air in most countries are driven by the

[2] The Second West to East gas pipeline was constructed by the China National Petroleum Corporation (CNPC) and completed in 2010. It transports Central Asian gas from the Kazakhstan - Xinjiang border to Guangdong Province in the southern coast. This is different than the first West to East gas pipeline (referred to simply as the West to East gas pipeline), from Xinjiang to the Yangzi River Delta (Shanghai/Zhejiang) built by the CNPC and completed in 2004.

physical properties of gas mixtures of methane in air. Common international best practice prohibits the transportation and utilization of gas mixtures within the explosive range (5 percent to 15 percent), and most countries have safety regulations that require an additional safety margin. These limits are country specific and range from 1 percent to 25-30 percent of methane in air under ambient conditions (UNECE, 2008). Over 70 percent of the recovered CMM in China has a concentration of less than 30 percent (IEA, 2009.1). China's Ministry of Environmental Protection established an emission standard for CBM / CMM in April of 2008 that prohibits emission of methane from CBM/CMM drainage systems and specifies that CMM drainage systems with greater than 30 percent methane concentration must use or flare the gas. Regulations requiring use of high-quality methane call into question the additionality from the CDM perspective of high-quality CMM recovery and utilization projects. Recently the UNFCCC has reviewed proposed projects that aim to use high-quality methane and have allowed them to be registered.

In Anhui, the cities of Huainan and Hefei have a number of commercial and industrial plants that could utilize natural gas. Several town gas projects have also been successful. In Anhui, the recent average wholesale price is 0.345 RMB/kWh; however, mines such as the Liuzhuang mine may pay as high as 0.85 RMB/kWh peak-period power rates, and during more typical conditions, 0.57 RMB/kWh. These rates make mine site power projects look attractive in Anhui. Regarding natural gas prices, the city gate price paid in Anhui from the West-to-East Pipeline is similar to retail prices paid by automotive CNG users in Chongqing and similar long-distance pipeline customers in Guizhou.

Chongqing has one of the oldest and best-developed natural gas distribution infrastructures in China due to its proximity to the Sichuan gasfields. The Chongqing electrical distribution system is dominated by the Chongqing Power Company, a subsidiary of the Central China Grid Company which accounts for about 78 percent of total supply, with the remainder coming from small regional grids and self-owned power plants of industrial enterprises. While the Chongqing Power Company itself has modest peaking power generation capacity, generation and transmission/distribution are fundamentally separated under the power system reforms of 2002. Chongqing has a variety of successful CMM projects including VAM destruction, town gas, boiler fuel, power generation, and LNG.

Chongqing benefits from low-priced hydro power with wholesale prices between 0.2 and 0.3 RMB per kWh, significantly lower than the 0.48-0.50 RMB per kWh obtained for gas fired power. Chongqing's regulated natural gas prices are some of the lowest in China in because of its proximity to the gas source and because of its long history of gas use.

Hebi City receives natural gas via a trunk line from the West-to-East pipeline which supplies gas to northern Henan province, including the cities of Xinxiang, Anyang as well as Hebi. Hebi has a well developed gas distribution system.

Henan province is the sixth largest provincial consumer of electricity in China. Large electricity consumers include electricity-intensive industries such as magnesium producers, due to the region's extensive dolomite resources, and cement manufacturers, such as the Tongli Cement Company which used 170 million kWh in 2007. Henan province has a variety of CMM project types including VAM destruction, combined heat and power, and power generation. Hebi has two power generation projects.

Hebi area electricity prices and natural gas prices are both similar to Chongqing, although commercial customers in Hebi pay a high 0.73-0.80 RMB per kWh. The Hebi region benefits from its relative

proximity to gas supplies from the Ordos Basin and as such, natural gas prices are lower than on the east coast.

The Guizhou power grid is one of five interconnected provincial grids which are controlled by the state-owned China Southern Power Grid Company (CSPGC). Guizhou has become an important electricity supplier to nearby Guangdong and it is expected that Guangdong will continue to depend on significant volumes of electricity purchase from Guizhou and other CPSGC provinces for the foreseeable future.

Currently natural gas in Guizhou is limited to LNG trucked in and used for a small number of residential and automotive customers. Guizhou's pipeline network is expected to expand with the China National Petroleum and Gas Corporation (also known as CNPC or PetroChina) pipeline from Burma completing in 2013. The trunk pipeline will enter Guizhou from Yunnan Province to the west and run a reported 300 km eastward through Anshun Municipality, Guiyang, Duyun Municipality, Dushan and Libo Counties and onward to Guangxi Province. The Guizhou Gas Group has developed preliminary plans for a network of branch pipelines from the trunk line, including a line that would run north from Guiyang towards the city of Zunyi. These developments increase the potential viability of different kinds of CMM projects, as currently no CMM is known to have been used outside of the immediate mining areas. Guizhou has two CMM projects, a power generation project and a town gas project.

Guizhou coal fired power wholesale prices are slightly lower than other provinces. Guizhou's electric power is expected to remain strongly cost competitive in view of the availability in Guizhou of inexpensive local coal and water resources. Guizhou is a largely untapped gas market, thus gas prices are based mostly on pipeline and LNG prices. Cities served by long-distance pipelines are paying a high 2.5-3.0 RMB/cubic meter.

Throughout China there a number of successful CMM projects. China has 64 operating projects within 13 provinces. China is host to over 40 CMM projects registered as CDM projects. Shanxi has the most projects at 23. The Huainan and Huaibei mining groups have had success with numerous projects in Anhui province Anhui has three registered CDM projects: Huaibei Haizi and Luling Coal Mine Methane Utilization Project, Anhui Huaibei Taoyuan Coal Mine Methane Utilization Project, and Anhui Huaibei Qinan Coal Mine Methane Utilization Project.

Chongqing has four operating CMM projects (GMI, 2011). Three projects are registered CDM projects: Zhongliangshan Coal Mine Methane Project, Nantong Coalmine Methane, and Tianfu Coalmine Methane Project. The Chongqing Datong Coalmine VAM Destruction and Utilization Project has requested registration. This system is expected to reduce greenhouse gas emissions by up to 200,000 tons of CO2e per year (CMOP, 2010). Chongqing is also home to the world's largest CMM purification and liquefaction project underway as of 2010, a project made possible by a USEPA-funded feasibility study.

Henan has nine operating CMM projects and the Hebi area has two. Henan is home to one registered CDM project, Jiaozuo Coal Mine Methane (CMM) Power Generation Project of Jiaozuo Coal Industrial Group Co. Ltd., Jiaozuo City, Henan Province. Guizhou has two operating CMM projects and several in development. Two CMM projects from Guizhou are at the validation phase of the CDM process.

# 2. Introduction

This document reports the energy market analysis of several comprehensive coal mine methane (CMM) recovery and utilization feasibility studies that were conducted as a part of a larger initiative funded by the United States Environmental Protection Agency (USEPA). This initiative supports USEPA's efforts under the Global Methane Initiative (GMI), formerly the Methane to Markets Partnership (M2M). On 1 October 2010 thirty-eight governments, the European Commission, the Asian Development Bank, and the Inter-American Development Bank launched GMI to urge stronger international action to fight climate change while developing clean energy and stronger economies. GMI builds on the existing structure and success of M2M to reduce emissions of methane, while enhancing and expanding these efforts and encouraging new resource commitments from country partners. GMI is fostering international collaboration to advance methane capture and use projects that bring more gas to market.

## 2.1 Background – source of data and analysis

Much of the data in this report comes from China's National Reform and Development Commission (NDRC), National Bureau of Statistics of China (NBSC), and the China Energy Statistics Yearbook (CESY); as well as various news stories and analytical reports such as those completed by the International Energy Agency (IEA). Analysis and interpretation of market data was completed by experts with various USEPA contractors, including Raven Ridge Resources and Advanced Resources International.

### 2.1.1 Background info on EPA feasibility studies in China

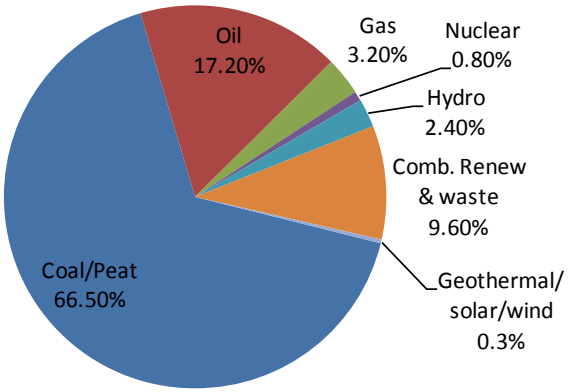
USEPA's Coalbed Methane Outreach Program (CMOP) has launched five full-scale feasibility studies of coal mine methane recovery and utilization projects at Chinese coal mines. The studies assess the technical and economic viability of implementing methane recovery and utilization projects, with detailed findings and project implementation recommendations compiled in comprehensive final reports. The information in this study comes from three completed feasibility studies: Feasibility Study of CMM Utilization for Songzao Coal and Electricity Company Coal Mines (May 2009), Feasibility Study for CMM Drainage and Utilization at Liuzhuang Coal Mine, Huainan Coal Field (February 2010), and Feasibility Study of CMM Utilization for Guizhou Nengfa Power Fuel Development Co., Ltd. Linhua Mine Located in Guizhou Province (December 2010), as well as the soon to be completed Feasibility of Improved Coal Mine Methane Drainage and Use at the Mines of the Hebi Coal Industry (Group) Corporation, Limited. The studies used in this report can be found at http://epa.gov/cmop/international/china.html.

Note that these reports, specifically the report for Songzao Coal and Electricity Company Coal Mines, which covers the energy markets of Chongqing, was written in 2008 and 2009 and data and market conditions have changed. For example, this document reports that the electricity market in Chongqing is expected to be soft for some time; however, it is known that this market has recently become more robust.

## 2.2 China's energy use

Coal dominates China's energy market with an estimated 66-71 percent contribution to energy needs in 2008 (EIA, 2010; IEA, 2010.1) (**Figure 6** and **Figure 7**). EIA envisages coal's share of the total energy mix to fall to 62 percent by 2035 due to anticipated increased efficiencies and China's goal to reduce its carbon intensity. China plans to reduce carbon emissions per unit of GDP by at least 40 percent from 2005 levels by 2020. Absolute coal consumption, however, is expected to almost double due to economic growth. China has also announced plans to reduce its energy intensity levels (energy consumed per unit of GDP) by 31 percent from 2010 levels by 2020 and increase non-fossil fuel energy consumption to 15 percent of the energy mix in the same time period (EIA, 2010).

**Figure 6** and **Figure 7** below show estimates of various components' contributions to China's energy mix as estimated by the IEA and the US Department of Energy's Energy Information Administration (EIA).



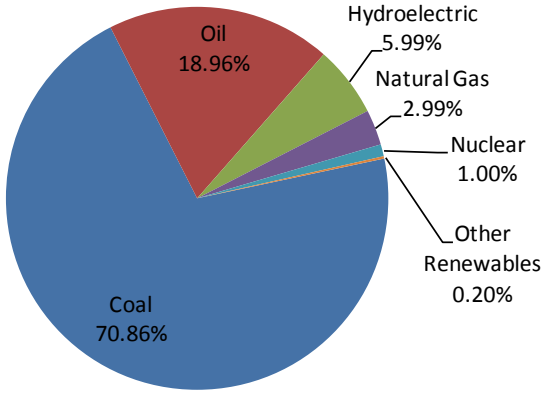




**FIGURE 6: CHINA'S ENERGY MIX, SOURCE: IEA (2010.1)** **FIGURE 7: CHINA'S ENERGY MIX, SOURCE: EIA (2010)**

## 2.3 Summary of China's CMM Activity

Ongoing CMM projects are found in 16 countries. China, Australia, Czech Republic, Germany, Poland, United Kingdom, and the United States in particular host numerous projects at active mines, while Germany, Ukraine, United Kingdom, and the United States host many projects at abandoned mines. China leads the world in CMM projects with 64, reducing CMM emissions by 31.8 MmtCO2e with boiler fuel, combined heat and power, industrial use, power generation, town gas, VAM destruction, and vehicle fuel projects. Australia and the United States follow with reductions of 9.1 and 7.0 MmtCO2e, respectively (GMI, 2010).

## 2.4 How to use this document if undertaking CMM projects in China

This document is intended to be used by project developers and carbon finance groups seeking CMM and VAM emissions reduction opportunities in China. This document provides information and analysis that can be used to inform decision making processes as a project's scope, location and pro forma economics are being considered. Information provided herein can aid the developer in determining the type of emission reduction project that is best suited for the region based on access to infrastructure that will deliver the product to market, potential customers, and expected range in market prices. The

user should conduct due diligence before undertaking a CMM or VAM emission reduction project in China as the provincial level economy changes rapidly.

The mines that were subjects of the aforementioned feasibility studies, as well as several completed or underway CMM projects, are referred to in many sections of this report as examples of what can be done if market research is solid and mine management sees the benefit to commercial project implementation.

# 3. Coal Market

## 3.1 National Coal Market Overview

### 3.1.1 Growth in China's Coal Production

The large number of suppliers, and in particular the significant role played by small, lightly regulated mines owned by local governments or private interests, cause official coal production statistics to be less accurate than those of other forms of energy such as electric power and natural gas. While the overall patterns described below are based on recently reported official statistics or estimates and are reasonably reliable, some of the specific numbers may diverge from the underlying reality, and some inconsistencies can be seen when comparing statistics from different sources. In particular, certain statistics (e.g., provincial reports on annual output based on "mines of scale") appear to leave out a substantial portion of small mine production. Even national total output statistics contained in official documents, which try to account for the entirety, are on occasion revised after release.

### 3.1.2 Supply/Demand

Coal has consistently accounted for 65-70 percent of China's primary energy in recent years, with consumption rising by an estimated 10 percent per year from 2000 to 2009 to a level of 3.0 billion tonnes (**Table 1**), (assumed thermal value 5000 kcal/kg). Despite official calls to gradually reduce the weight of coal in the energy mix, the percentage actually increased slightly between 2005 and 2009 as heavy industry surged.

**TABLE 1: ESTIMATED COAL CONSUMPTION IN CHINA, 2000 - 2007 (MILLION TONNES, 5000 KCAL/KG THERMAL VALUE AVERAGE)**

| | 2000 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|
| Volume | 1,320 | 2,167 | 2,390 | 2,580 | 2,810 | 2,958 |
| Percentage of total primary energy | 68.0% | 68.9% | 69.4% | 69.5% | 70.3% | 70.4% |

Sources: CESY (2010), p. 53; NDRC (2008.1)

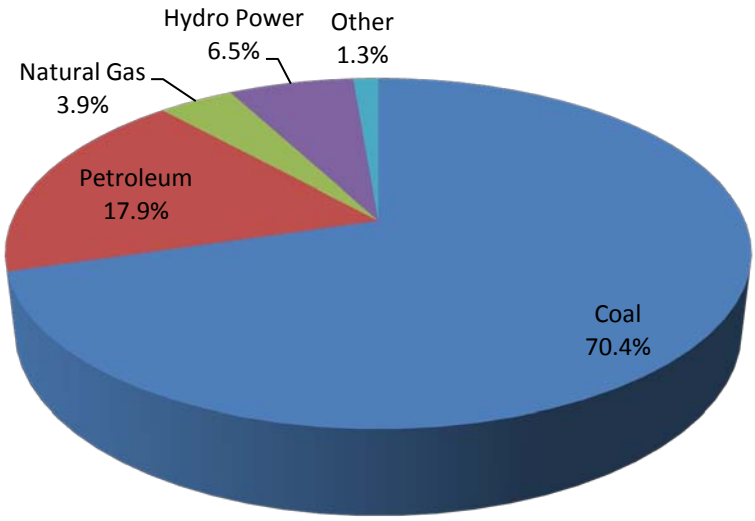



**Figure 8** below shows the prevalence of coal in the mix of China's primary energy sources.

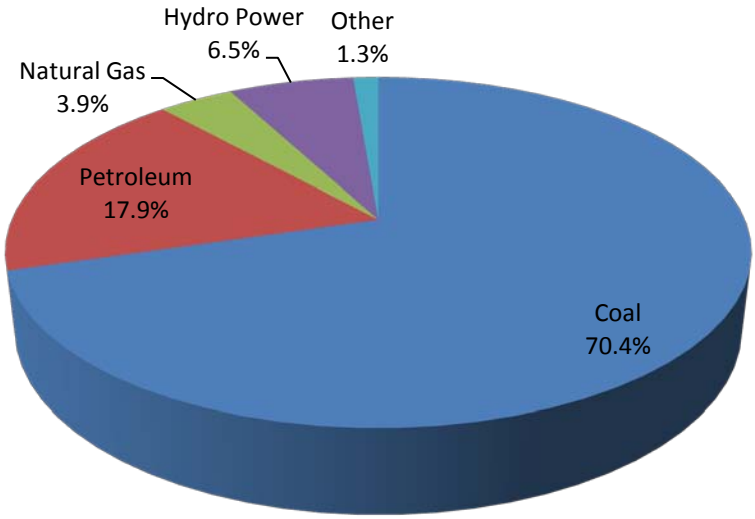



**FIGURE 8: CHINA'S PRIMARY ENERGY SOURCES, 2009**

Domestic coal production has strained to keep pace with rapidly growing demand in recent years. Although overall output grew by the same 10 percent per year as consumption between 2000-2009, the most rapid growth took place in 2003-2005, the years immediately following the government's decision to largely free coal prices. Since 2005, by contrast, the rate of growth has steadily decreased, with the mix of coal production, import and exports shown in **Figure 9** below.

**TABLE 2: RAW COAL SUPPLY IN CHINA**

| | Production | | Exports | | Imports | |
|---|---|---|---|---|---|---|
| | Million tonnes | Growth (%) | Million tonnes | Growth (%) | Million tonnes | Growth (%) |
| 2000 | 1,299 | - | 55.1 | - | 2.2 | - |
| 2001 | 1,382 | 6.4 | 90.1 | 33.8 | 2.7 | 18.5 |
| 2002 | 1,455 | 5.3 | 83.9 | (7.4) | 11.3 | 76.1 |
| 2003 | 1,722 | 18.4 | 94.0 | 10.7 | 11.1 | (1.8) |
| 2004 | 1,992 | 15.7 | 86.7 | (8.4) | 18.6 | 40.3 |
| 2005 | 2,204 | 9.9 | 71.7 | (20.9) | 26.2 | 29.0 |
| 2006 | 2,373 | 7.7 | 63.3 | (13.3) | 38.1 | 31.2 |
| 2007 | 2,526 | 6.41 | 53.2 | (19.0) | 51.0 | 25.3 |
| 2008 | 2,622 | 3.8 | 45.3 | (14.8) | 40.4 | (20.8) |

Source: CESY (2008), p. 33, 60; NBSC (2008); China Customs (2009.1)

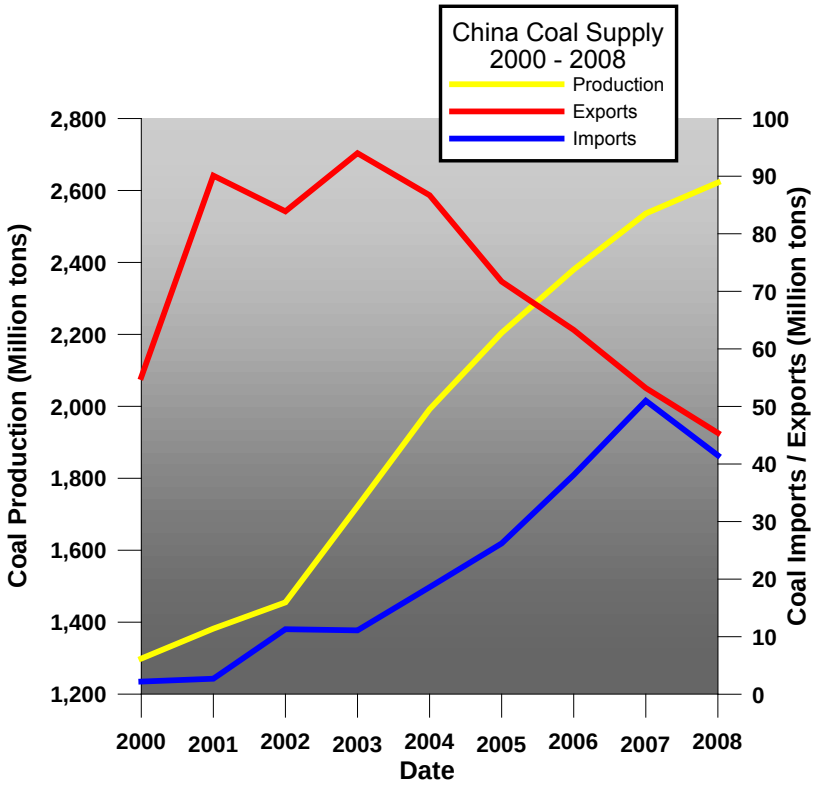



**FIGURE 9: CHINA'S RAW COAL SUPPLY**

As a result, coal exports, which had expanded steadily from the mid 1990s through 2003, declined by over 50 percent between 2004 and 2008. As domestic transport bottlenecks worsened and transport prices increased, imports of coal into eastern and southern coastal provinces increased to a level that virtually counterbalanced exports by 2007. These imports declined somewhat in 2008 to 41-42 million tonnes, approximately 1.5 percent of total national demand.

### 3.1.3 Coal Use

Thermal power generation, which grew at a nearly 15 percent rate through 2004-2007, has been the principal driver for coal industry expansion. In 2007, power plants consumed approximately 1.4 billion tonnes of coal, or 55 percent of the total. The steel industry, which grew at a 23 percent rate over the same period, consumed an estimated 17 percent (about 450 million), split approximately equally between direct burning and indirect consumption in the form of coke. Cement and coal-based chemicals accounted for an additional 11 percent of total consumption, with the remainder scattered among other usages (CESY, 2008, pp. 109-110).

### 3.1.4 Coal Production

*Coal type*

In 2007, output of coal by type was reported by knowledgeable sources as follows:

**TABLE 3: OUTPUT OF COAL BY CLASSIFICATION, 2007 (MILLION TONNES)**

| Classification | Coal Output (million tonnes) |
|---|---|
| Anthracite | 439 |
| Bituminous<br>*of which*<br>Coking Coal<br>Non-coking<br>Lignite | 1,937<br><br>979<br>958<br>146 |

The Chinese definition of coking coal, which follows former Soviet standards, covers a somewhat broader range of coals than the western definition does; only about 25 percent of "coking coal" is actually used to make coke. A substantial portion of China's anthracite coal is used for power generation, with much of the rest used as raw material for chemical production.

*Coal Production Company Ownership*

An estimated 49.1 percent of China's 2007 coal output originated from large scale, fully mechanized mines (mainly underground) operated independently, according to commercial principles, by approximately 100 companies owned by arms of provincial and central governments. This ownership structure represents the culmination of a commercialization process during the 1990s which transformed most of these companies from appendages of a central government Coal Ministry to independent (though still government owned) entities responsible for their own profits and losses. The two largest companies, Shenhua Energy and China Coal Energy, are owned by the central government; the remainder are owned by provincial governments. Shenhua produces close to 200 million tons of coal per year and also controls significant railroad, port, and power generation assets. According to official estimates, an additional 12.8 percent of 2007 coal output came from less mechanized companies owned by city and county governments. The remaining 40 percent was mined by an estimated 14,000 companies owned by townships, villages, and private interests. Both the scale and the level of mechanization at these mines are variable, and they account for a disproportionate share of accidents

and fatalities. In a number of cases, they impinge upon the reserves owned by larger mechanized mines.

The proliferation of these locally owned mines in response to the freeing of coal prices was an important factor behind the rapid growth in coal production during the period 2003-2006. The government regulated them relatively lightly during this period in the interest of ensuring adequate coal supply, but has been trying for several years to hold them to higher safety and technical standards. It has forbidden the commissioning of any new mines with annual capacity of less than 300,000 tonnes per year, and is attempting to shut down the least technically advanced and most dangerous of the existing locally owned mines. This effort probably accounts in part for the slower growth in coal production in recent years.

*Geographic Distribution*

China's coal reserves and production are disproportionately concentrated in the north-central part of the country as shown below in **Figure 10**. Shanxi Province alone accounts for over 600 million tonnes, or approximately 25 percent of national output, and neighboring Inner Mongolia, Shaanxi and Henan provinces for approximately 30 percent aggregate. The three northeastern (Manchurian) provinces provide 8-9 percent and the three provinces of Hebei, Anhui, and Shandong located south and east of Beijing and north of the Yangtze River account for approximately 13 percent.

By contrast, the major Yangtze Delta and Pearl River load center provinces of Jiangsu, Shanghai, Zhejiang, Jiangsu, and Fujian, and Guangdong only produce about 2 percent of the national total. These areas depend heavily on coal transported by rail from the north central provinces (particularly Shanxi, Shaanxi and Inner Mongolia) to northern coastal cities such as Qinhuangdao, Huanghua and Tianjin, and by ship from these cities to their ultimate destinations, supplemented in recent years by imports from abroad. The seven inland provinces south of the Yangtze River (Jiangxi, Hubei, Hunan, Chongqing, Sichuan, Guizhou, Yunnan) account for approximately 23 percent of the country's population, and 17 percent of its coal production. Guizhou, at approximately 125 million tonnes per year, is the major producer of this group. Although the quantity, coal quality, and mining conditions of deposits in these provinces (excepting Guizhou) are generally inferior to those in the north, they are nonetheless being developed to the maximum extent, with northern coal relegated to a supplementary role due to limited north south rail transport capability and high transport expense (CESY 2008, p.109).

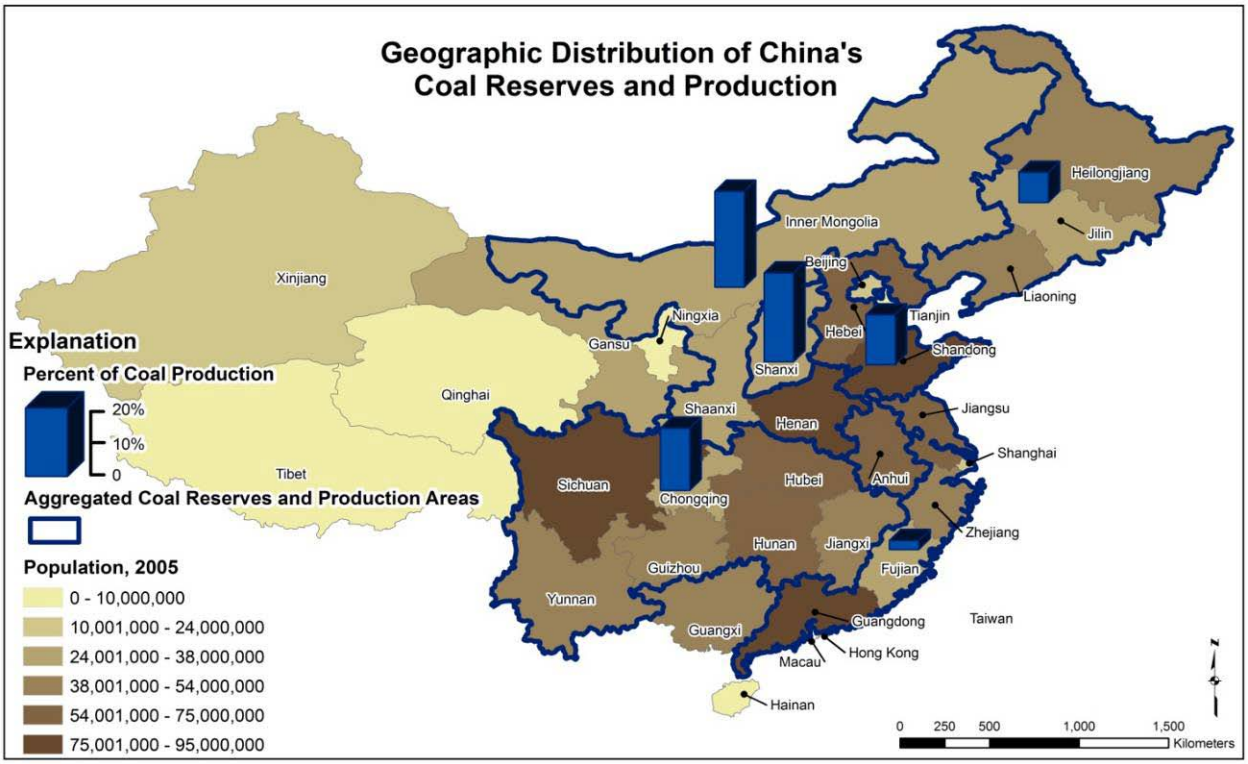



**FIGURE 10: GEOGRAPHIC DISTRIBUTION OF CHINA'S COAL RESERVE AND PRODUCTION**

### 3.1.5 Marketing and Pricing

As the central government released control of the large mines to provincial governments during the late 1990s and the turn of the 21st century, it also gradually relaxed control of marketing and pricing in order to ensure an adequate supply of the country's most important source of primary energy. This decision, together with a sustained upsurge in coal demand (which had actually dropped in the late 1990s) transformed the large mechanized companies from money losers to money earners by 2002, and succeeded in greatly increasing coal production.

One institution from the centrally planned economy was retained: the annual national coal marketing meetings at which supply agreements are reached between key coal producers and the most important consumers, who were formerly directly covered by central planning. These agreements fix volumes and prices for the coming year; the pricing is referred to as "contract pricing", or "long-term contract pricing", as distinct from spot pricing. Only rarely does a "long-term" contract have a duration longer than one year.

In 2007, approximately 850 million tonnes of coal – or about two thirds of the output of the major mechanized companies - were sold at the meetings. About three quarters of this volume was purchased by electric power plants, represented in cartel-like fashion by the five national generation companies, with the remainder split between large steel, cement, chemical, and coal exporting companies. The contracts have traditionally satisfied only a portion – perhaps half to two-thirds – of the large power plant customers' needs, and a smaller percentage of the needs of industrial customers.

While the central government does not directly dictate prices for coal sold at these meetings, the National Development and Reform Commission (NDRC) is a participant, and retains a final veto power in extreme circumstances. NDRC's main goal in recent years, not always fully achieved, has been to ensure that prices to power plants do not rise more rapidly than their owners can bear, in view of the strict central price controls on power sales which severely limit the degree to which the power plants can pass price increases through to their customers. Other classes of coal consumers are for the most part left to fend for themselves in price negotiations with the sellers.

The central government also guarantees rail transport for all coal sold at the annual sales meetings (rail operations are still directly managed by the Ministry of Railroads). The transport guarantee is an important consideration for transactions involving long distance, trans-provincial shipping in a country in which rail capacity has been chronically insufficient to meet demand.

Provincial governments exercise more direct price controls on an ad hoc basis. In Chongqing, for example, the local government has put a strict upper limit on coal sold to local power plants by its largest producers.

The approximate one-third share of output of the large mechanized mines remaining after the annual supply meetings, as well as virtually all of the output of the smaller locally or privately operated mines account for 38 percent of national total output and are sold under short term contracts at spot market prices. These spot market prices have been substantially higher than the national sales conference contract prices in recent years.

### 3.1.6 Recent Market Trends

*Coal Price Increases 2007 – 1st-half 2008*

As the economy, and in particular major coal consuming industries such as electric power and steel grew at 13-15 percent rates and a sellers' market psychology took hold, coal prices increased dramatically in 2007 and the first half of 2008. The ex-mine price for one-year contract coal power plant (see above) sold by major producers in Shanxi rose by 20 percent to a reported 490 RMB ($72) per tonne for 5500 kcal/kg steaming coal in 2008. Prices charged by mines for power plant coal spiked as high as 600-700 RMB ($88-103) per tonne in the first quarter of 2008.

The sudden upsurge in steam coal prices created particular problems for power plants, whose ability to absorb the increases were limited by central government controls on the prices the plants could charge to the grid for their output. Coal which they could purchase at one year contract prices could fulfill only a portion of their needs; large and small coal producers alike preferred to direct their sales to other industrial users such as cement plants, who were not limited by ceilings on the price increases they could pass to their customers. As a result, coal stocks ran dangerously low at power plants throughout the country in the early months of 2008. Only at mid-year did the government grant thermal power plants some relief through two price increases that raised the per kWh thermal power sales price to the grid by about 0.04 fen (0.006 US cents) per kWh on average, allowing the plants to recoup coal cost increases of about 88 RMB per tonne (at 5000 kcal/kg coal and 38 percent coal conversion efficiency in the plants).

The market price run-up for coking coal sold to steel mills or independent coking plants rose even more dramatically to 800 – 1000 RMB ($117-$147) per tonne at year-end 2007 depending on quality to 1400 RMB ($206) per tonne in the first quarter of 2008 . By mid-year spot coking coal was sold for as much as 2000 RMB, or almost $300 per ton. On June 30, the government took the step of freezing coal prices for the remainder of the year.

*Coal Price Decreases in 2nd- half 2008*

The Chinese economic slowdown of fourth quarter 2008, and most particularly the average 11.4 percent and 13.3 percent declines (year-to-year basis) in production of thermal power and steel during the quarter has reduced coal demand by as much as 12 percent and thus dramatically changed the dynamics of the coal market in China. While there was some lag in reaction time, coal production started to follow the trend of consumption, with a 1.3 percent drop in December 2008 compared to December 2007. Spot prices for steaming coal charged by mines in Shanxi were reported in late November to have dropped from a range of 600-700 RMB ($94 – 110) per tonne to 450-500 RMB ($71 – 78) per ton, and for high-quality coking coal from 1800 ($282) to about 1300 RMB ($204) per ton, considerably lessening, though not eliminating, the gap between spot and contract prices.

Although spot prices for all kinds of coal have decreased, the drop has been most pronounced for lower quality coal (low thermal value, high ash and/or high sulfur). Tens of millions of tonnes of such coal were reported to have accumulated at the major northern transshipment ports in the last two months of 2008.

While prices for the higher-quality coal sold by the major mines to their key customers under the on-year contracts appear to be holding up better as of the beginning of 2009, it remains unclear in what direction they will move over the longer term. Participants at the annual sales conference for 2009 held in December 2008 report a deadlock in the negotiations between the coal seller and power plant buyer cartels, with the former demanding a 10 percent increase over 2008 contract prices, and the latter a 10 percent decrease. It is logical to expect that the spot price drop will facilitate the central government's efforts to close down the least productive and most dangerous of the locally controlled small mines, which together with moves by some mines to withhold production while prices are low, could moderate coal price drop through reduction in supply. But it remains unclear how deep and how long-lasting the drop in coal demand will be, and what will be its long-term impact on coal pricing.

## 3.2 Provincial level

### 3.2.1 Anhui

Anhui Province is located in eastern China across the basins of the Yangtze River and the Huai River. Anhui is shown in **Figure 11** below.


**FIGURE 11: MAP SHOWING ANHUI PROVINCE**

Anhui Province experienced an average 9.0 and 10.7 percent per year growth in coal production and consumption, respectively, from 2006-2010 (**Table 4**). Neither consumption nor production showed the fluctuations seen in many other provinces in 2008 and 2009 as a result of the global economic crisis.

**TABLE 4: ANHUI PROVINCE COAL PRODUCTION AND CONSUMPTION, 2005-2010**

| Year | Production | Consumption |
|---|---|---|
| 2005 | 84.88 | 83.4 |
| 2006 | 83.32 | 88.31 |
| 2007 | 92.66 | 97.84 |
| 2008 | 110.79 | 113.77 |
| 2009 | 123.98 | 126.66 |
| 2010 | 130.30 | 138.44 (est.) |

Source: CESY 2010, pp. 35, 83; Anhui Statistics Bureau 2011

*Demand*

As the coal production base closest to the major consumption centers in the East China coastal provinces, Anhui's coal production has been driven by demand in these provinces as well as by growth in Anhui itself. This trend is reflected partly in physical transfers to the neighboring provinces, which rose by 15 million tons from 2005-2009 (**Table 5**).

**TABLE 5: COAL TRANSFERS INTO AND OUT OF ANHUI (MILLION TONS)**

| Year | Into Anhui | Out of Anhui |
|---|---|---|
| 2005 | 23.74 | 25.65 |
| 2007 | 33.64 | 29.51 |
| 2009 | 33.65 | 40.09 |

Source: CESY 2011, p. 166

As time passes, however, external consumption of Anhui coal is increasingly taking the form of electricity purchases from coal-fired power plants built in Anhui. Anhui's total power plant capacity, approximately 95% of which is coal-fired, rose nearly 150 percent between 2005 and 2010 to 29,500 MW (Anhui Energy Administration, 2011). Of the newly added 17,200 MW, 7600 MW, or 44%, consisted of coal-fired plants built with coastal province investment dispatching their output directly to the coastal provinces through the East China power grid under the so-called "Anhui Electricity to the East"[3] program (ChinaPower, 2009).

Electricity generation for both in and out- of- province users has been the strongest driver for increased coal use in Anhui (**Table 6, Figure 12**). Coal consumption by power plants nearly doubled between 2005 and 2009, rising from 37 percent to 44 percent of total consumption. As is the case elsewhere in China, the cement, steel, and chemical industries are the other important consumers of coal. [Industrial consumption may have been anomalously low in the first six months of 2009 due to the global economic slowdown, which had a strong impact on the building material and metallurgical sectors throughout China.

[3] "Anhui Electricity to the East" refers to the construction since 2005 of a series of large thermal power plants near the Anhui coal fields and high voltage transmission lines to connect them to load centers in the Yangzi Delta Provinces.

**TABLE 6: ANHUI COAL CONSUMPTION BY SECTOR, 2005-2009**

| | 2005 | 2007 | 2009 |
|---|---|---|---|
| Electricity | 30.8 | 39.6 | 58.3 |
| Coking | 7.7 | 8.5 | 10.9 |
| Industry | 33.1 | 38.7 | 44.3 |
| Residential | 5.8 | 4.3 | 3.1 |
| Other | 6.0 | 6.7 | 9.9 |

Source: CESY 2010, p. 166; CESY 2008, p.166; CESY 2006, p. 170

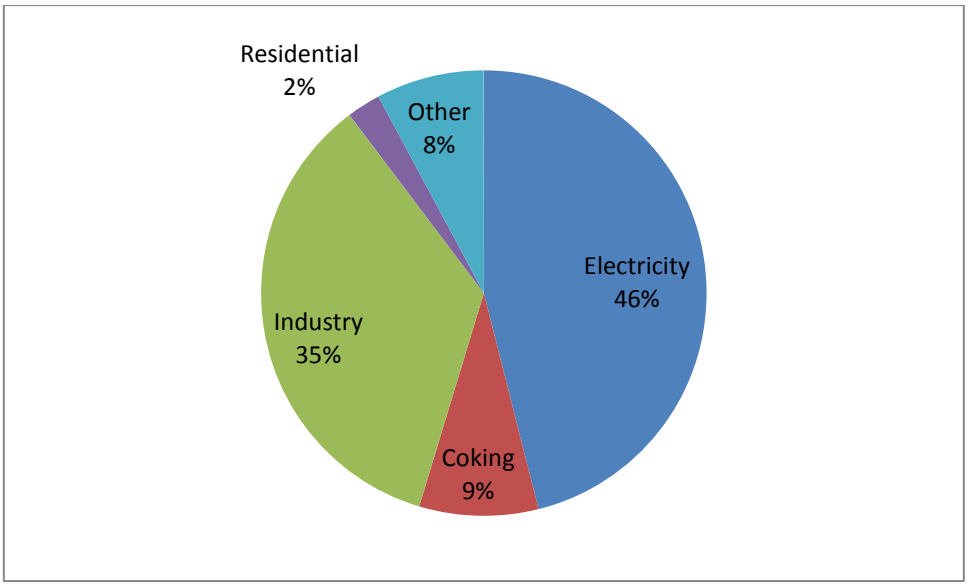



**FIGURE 12: ANHUI COAL CONSUMPTION BY SECTOR, 2009**

*Future Coal Consumption Growth in Anhui*

Electricity consumption throughout the East China region will continue to drive Anhui's coal consumption over the coming five years. As is the case throughout China, there is increasing discussion of developing alternatives to fossil fuel power.

Although Anhui does not have appreciable hydropower potential and does not have ideal wind conditions for wind-power, it is developing some wind power facilities together with Shanghai investors. The national power generation companies and nuclear power plant developers are also doing preliminary studies for as many as 4 large nuclear power plants in Anhui (Anhui News, 2011.2).

The Japan Fukushima nuclear accident will, however, at the very least slow down these plans. The fact that the second phase of the "Anhui Power to the East" program has been officially listed in the 12$^{th}$ five year plan for 2011-2015 (ensuring, among other things, access to low interest state bank loans) signifies that for at least this period of time, there will most likely continue to be large-scale development of coal-fired power plants in Anhui aimed at the East China regional market (Anhui News, 2011.2).

The East China Power Grid Company is continuing to invest large resources into new transmission lines connecting Anhui generation hubs to the coast, and 16,000 MW of coal-fired capacity are in the feasibility study/design stage throughout the province, approximately equal to the amount added from

2006-2010 (China News Agency, 2011; Anhui Daily, 2011). Assuming approximately 44 percent thermal efficiency that is characteristic of the ultra-supercritical power plants now being built in China, 6000 hours of production per year, and average coal thermal value of 5000 kilocalories per kilogram, an additional 38 million tons of additional coal will be consumed per year in the power sector.

The price squeeze on electric power generators resulting from rapidly rising coal prices and the central government's reluctance to raise electricity prices is a potentially complicating factor which has caused electricity generators in certain parts of the country to decrease their coal purchases in 2011. This squeeze has been most pronounced, however, in cases where the generators must import coal from distant smaller mines, not for mine-mouth power plants such as those in Anhui which with dedicated suppliers who themselves are investors in the power plants.

According to one report, the prices charged by the mines to the Anhui mine-mouth power plants under contracts (most likely one-year duration) was approximately 200 yuan (25 percent) lower than spot prices (Shenyin and Wanguo Securities, 2011). This suggests that the probability that the coal price squeeze will affect Anhui coal consumption is low.

Consumption growth in industry may be somewhat slower (7-8 percent) than in the electric power sector with the gradual transition of the national economy from investment towards consumption. If this is the case, overall growth in demand might be in the range of 8-9 percent.

*Demand for Anhui Coal in Neighboring Provinces*

The shortages of coal in the eastern coastal provinces and the expense to these provinces of bringing in coal from the north-central mining hubs of Shanxi and Inner Mongolia virtually ensure that Anhui will be able to ship as much coal to neighboring provinces as it is capable. As reflected in **Table 5** above, the traditional surplus in Anhui's coal shipments to outside provinces over its coal imports from other provinces has gradually eroded with growth in provincial demand. According to the China Coal Society, this surplus disappeared completely in 2010, as the Anhui mines came under pressure from provincial authorities to satisfy the needs of Anhui customers first (CCII, 2011).

Coking coal shipments from the Huaibei Mining Group to customers such as Shanghai Bao Steel Group, which amount to 5-10 million tons per year at present will likely continue, and will perhaps grow; the steel mills are investing in the development of new capacity (Bao Steel, 2011). As discussed above, the mines will have incentive to sell as much steaming coal as they are allowed to outside the province given the high market prices. The precise volumes shipped outside the province will depend on how fast coal production is expanded.

*Production and Industry Structure*

Unlike a number of other major coal producing provinces, hardly any of Anhui's coal production originates from smaller, less mechanized mines owned by sub-provincial governments or private interests. Over 85 percent of the province's 130 million tons of raw coal in 2010 originated from two large provincially-owned mining groups:

- Huainan, 80 million tons, almost entirely bituminous steaming coal (Anhui365Net, 2011);

- Huaibei, 32 million tons, approximately one third coking coal and the remainder bituminous steam coal (Anhui365Net, 2011).

Smaller producers, include:

- Xinji Group in Huainan, which owns four large mines with 8.3 million tons capacity and whose largest investor is the central-government owned State Development Investment Corporation (East Money, 2011).
- Wanbei (North Anhui) Coal and Electricity Company in Suzhou City, 14 million ton output in 2009 (Wanbei Website).

Huainan has announced a goal to increase output by 20 million tons to 100 million during the 12th five year plan, while Huaibei has put forth a perhaps over-ambitious target to increase in-province production by 50 million tons, which if fulfilled, would mean a 10 percent annual output increase from the two companies (Anhui365Net, 2011; Huaibei Coal, 2011). Like many producers in older mining areas, however, both companies are investing significantly in less developed deposits in the northern and western provinces such as Inner Mongolia.

### 3.2.2 Chongqing

Chongqing is a major city in central China and one of the five national central cities. Chongqing serves as the economic center of the Upstream Yangtze area and is both a major manufacturing center and transportation hub for Southwest China. Chongqing Municipality is shown in **Figure 13**.

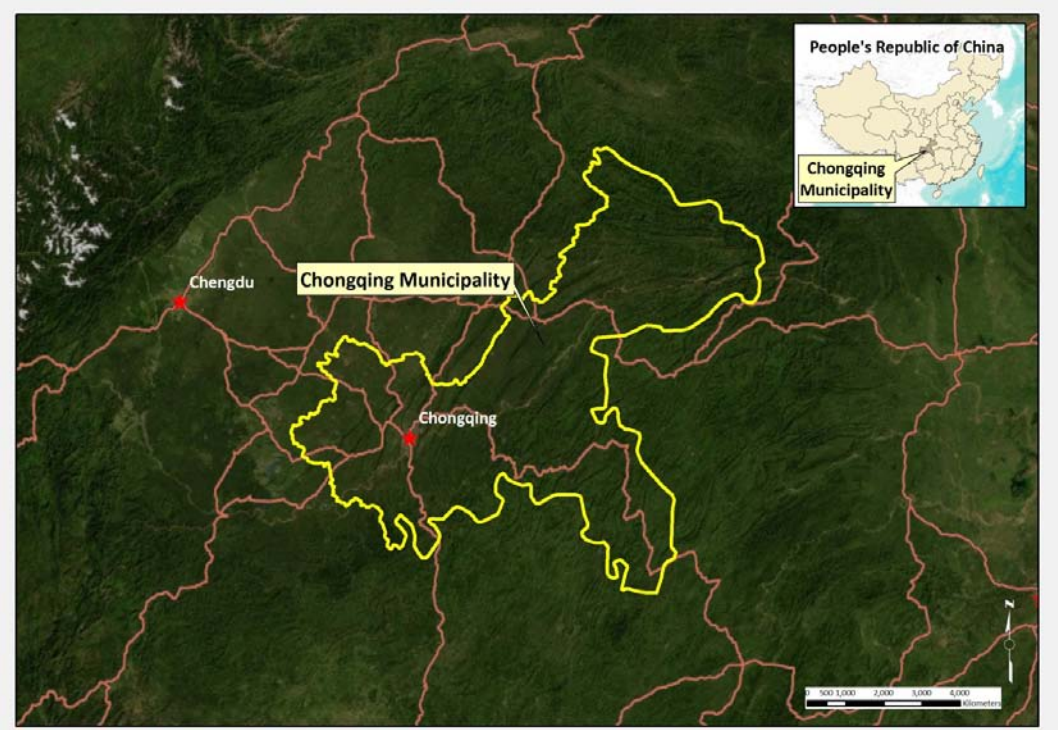



**FIGURE 13: MAP SHOWING CHONGQING MUNICIPALITY**

*Supply and Demand*

Coal consumption in Chongqing climbed steadily with economic growth from 2005-2007 to a reported 42.9 million tonnes. Power plants, reported by a number of different sources to have consumed about 15 million tonnes in 2007, are the most significant end-users, at approximately 35 percent of total coal consumption.

**TABLE 7: ESTIMATED COAL CONSUMPTION AND PRODUCTION IN CHONGQING (MILLION TONNES)**

| | 2005 | 2006 | 2007 |
|---|---|---|---|
| Consumption (million tonnes)<br>- Power Plants<br>- Steel | 33.3<br>NA<br>NA | 37.4<br>12<br>NA | 40.8<br>15<br>3.5 |
| Production | 36.2 | 39.9 | 42.9 |

Source: CESY 2008, p.92, 109; Chongqing Economic Commission 2007

Historically, the difficulties of transporting coal over the mountains from the north have forced Chongqing to rely primarily on its own coal production, despite the difficult mining conditions and the mediocre quality (high sulfur content in particular) of the Chongqing deposits. Coal production has climbed steadily with consumption in recent years to a reported 42.9 million tonnes in 2007, of which approximately 27 million came from "mines of scale" according to the Chongqing Statistics Bureau. Production from these mines of scale are estimated to have reached 32 million tonnes in 2008, of which 12.4 million originated from the five largest coal companies, including SCEC, owned by the Chongqing Energy Investment Group.

Up to 6 million tonnes per year produced in the remote Three Gorges reservoir counties to the northeast are shipped down the Yangtze by boat. The larger mines closer to metropolitan Chongqing also sell outside the province, mainly to neighboring Sichuan. In 2008, Chongqing power plants purchased approximately two million tonnes from other provinces, approximately three quarters of which came from Shaanxi and Shanxi to the north, with the remainder entering from Guizhou to the south. Chongqing's steel mills purchased an additional 1-2 million tonnes of coking coal from outside the province.

*Marketing of coal by the Chongqing Energy Investment Group*

The Chongqing Municipal government, through the Chongqing Energy Investment Group (CQEIG), controls both the distribution and the pricing of 80-90 percent of the approximately 12 million tons of coal produced by the five mining companies under the CQEIG, including Songzao Coal and Electricity Company (SCEC). This coal is allocated mainly to the municipality's large power plants and steel mills, but only fills a part (perhaps 50-75 percent) of their demand, the remainder of which is met by coal from smaller local mines or spot purchases from outside the province. Coal sold by non-CQEIG-controlled mines to industrial users such as cement plants is sold primarily at market prices. In contrast to power plants, these facilities are free to adjust their sales price to cover coal purchase costs.

In 2008, the government controlled price for CQEIG coal sold to power plants (most of them partially owned by CQEIG itself) was 260 RMB per tonne (5000 kcal per kg), about half of the spot price in the first half of the year. This left little incentive for CQEIG's mines to sell any coal in excess of target to the power plants, and was an important reason why the power plants faced coal shortages for the first half of 2008. For a period of time, the municipal government resorted to administrative measures to block the sale of coal produced in Chongqing (both CQEIG and local mines) to industrial users in neighboring provinces at spot market prices in order to ensure adequate supply for the power plants.

### 3.2.3 Hebi Area/Henan Province

Henan Province is located in Central China and Hebi, located in the north of the province, is situated in mountainous terrain at the edge of the Shanxi plateau. Henan Province and Hebi are shown in **Figure 14**.

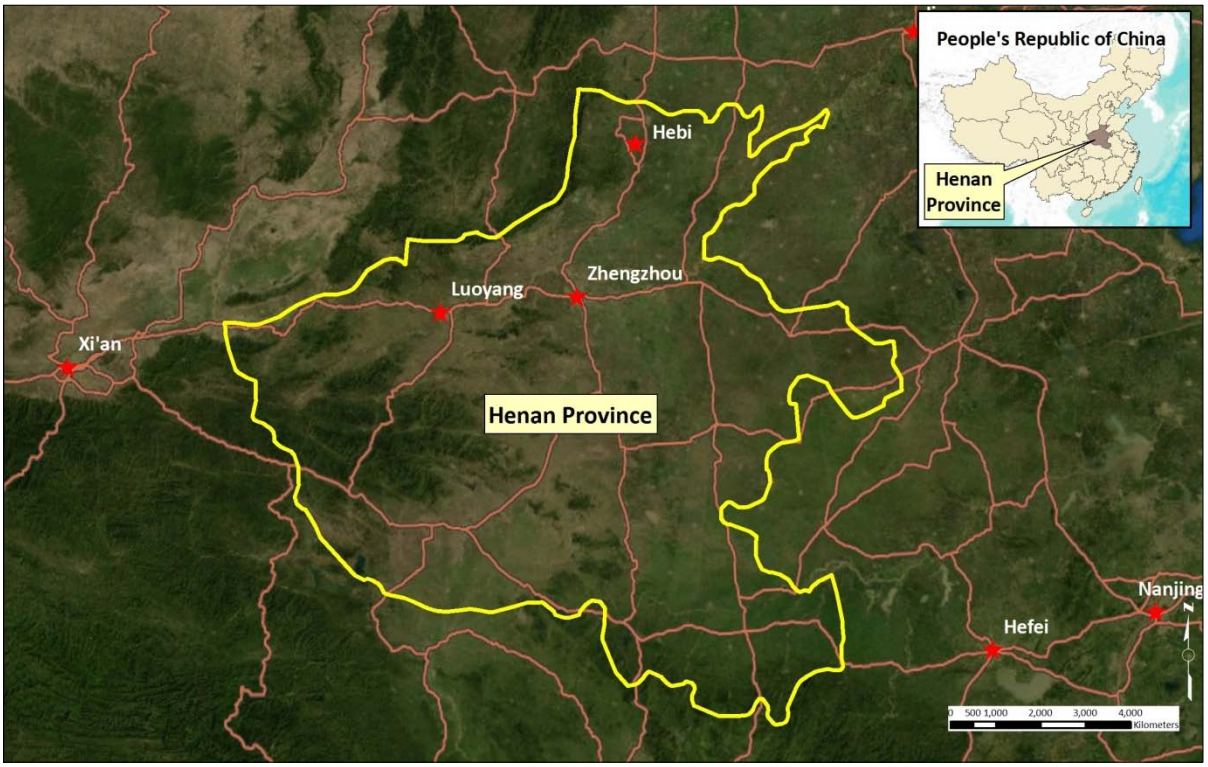



**FIGURE 14: MAP SHOWING HENAN PROVINCE**

Both supply and demand for coal in Henan experienced fluctuations between 2006-2010 as shown in **Table 8**. While some of these changes were due to short-term factors, the province's transformation from net coal exporter to net coal importer is likely to endure.

**TABLE 8: SUPPLY AND DEMAND FOR COAL IN HENAN, 2005-2010**

| | Production (million tons) | Consumption (million tons) |
|---|---|---|
| 2005 | 187.61 | 184.68 |
| 2006 | 195.32 | 210.03 |
| 2007 | 192.87 | 231.71 |
| 2008 | 208.87 | 238.68 |
| 2009 | 230.18 | 244.45 |
| 2010 | 213.49 | 270 (est.) |

Source: CESY 2010, pp. 35, 83; HSB 2011

*Supply and Industry Structure*

Henan is one of China's oldest coal producing regions and still one of its most important, accounting for approximately 7 percent of the country's total output according to official statistics, more than all but three other provinces. Growth has been far from steady, however, with official statistics (**Table 8**) showing stagnation between 2005-2007, sharp increases in 2008-2009, and a dramatic drop in 2010.

Variability in growth is directly connected to the fate of small (300,000 tons capacity or less), semi-mechanized mines owned by sub-provincial governments or by private entities which proliferated in Henan as coal prices were freed and demand throughout China for coal of all types boomed during the 2000s. The bulk of the growth in Henan's coal output during 2005-2009 originated from these mines, which accounted for 100 million tonnes, or 43.4 percent of the 230 million tonnes of officially reported total in 2009 (CCII, 2011; Henan Coal Society, 2010).

From the middle of the decade, the central government pushed to restrain the development of these mines in view of their poor safety and environmental record, as well as in the interest of efficient resource management. The stagnation of reported output in 2006-2007 coincides with the beginning of this push.

It is quite possible, however, that the initial result of the central government's pressure was under-reporting of output from the smaller mines by local governments eager to keep them open rather than closure of the mines and consolidation of the industry. Under-reporting would explain why, even as the official statistics suggest that Henan's coal output was less than its consumption, these same statistics show that Henan's shipments of coal to neighboring provinces surpassed its receipts of coal from neighboring provinces by tens of millions of tons per year (**Table 9**). Similar contradictions characterize the statistics for other provinces such as Shanxi and Shaanxi in which the central government, as in Henan was trying to bring the small mines under control.

**TABLE 9: COAL SHIPMENTS TO AND FROM HENAN (MILLION TONS)**

| | Shipments from Henan to other Provinces | Shipments from other provinces to Henan[4] | Net out-shipments |
|---|---|---|---|
| 2005 | 58.37 | 32.51 | 25.86 |
| 2007 | 69.10 | 46.13 | 22.97 |
| 2009 | 114.62 | 61.28 | 53.54 |

Source: CESY 2010, p. 182; CESY 2008, p. 182; CESY 2006, p. 186

By 2010, however, multiple sources agree that the government's crackdown on the smaller mines began to take stronger effect, and that the reported decline in 2010 provincial output resulting from shutdown and consolidation of these mines was real. The China Coal Society indicates that in 2010, Henan for the first time became a net coal importer, greatly reducing shipments to provinces to the south and east. It suggested that as many as 70 million tons of capacity – approximately one third of total 2010 provincial output – could be either shut down or amalgamated in 2011 (CCII, 2011).

The Henan Provincial government issued a directive in 2010 calling for production to be concentrated among approximately 5 modernized companies which at year-end 2009 controlled 173 large-scale mines, including:

- The Henan Coal and Chemical Group based in the north and east of the province, consisting of both anthracite and bituminous mines with reported 55 million ton output in 2009. Hebi Mining Group is one of HCCG's subsidiaries.
- The Zhongping Coal and Chemical group centered in the coking coal base of Pingdingshan in Central Henan, with reported 45.81 million tons output in 2009.
- The Yima Group in Western Henan, 22.6 million tons output in 2009.
- The Zhengzhou Coal Group near the provincial capital, 18.4 million tons output in 2009.
  The Shenhuo ("Sacred Fire") Group based in Shangqiu, East Henan, 5.7 million tons output in 2009 (Henan Coal Society, 2010)

The government's ultimate goal is for at least three of these companies to surpass 50 million tons capacity. In addition to developing their existing properties, they can be expected to acquire some of the more viable small mining companies.

Currently, these companies are developing new large-scale capacity at a pace of approximately 10 million tons per year aggregate (approximately 5 percent per year) (Henan Coal Society, 2010). Annual growth in Henan's coal output may be slightly higher than this once the small mine consolidation process is complete, and the surviving smaller mines expand their output as well. But the volume of untapped, mineable resources in Henan is not as large as in provinces to the north and west such as Shanxi, Inner Mongolia, and Shaanxi, which will be the major drivers of expanded coal output in China.

[4] Customers burning coal shipped in from outside provinces include power plants near the border with Shanxi, the premier supplier of high-quality steaming coal.

*In-Province Demand*

Coal consumption in Henan grew at approximately 8 percent per year 2006-2010 (**Table 10**). The considerably slower rates of 2008 and 2009 reflect a temporary decline for a period of months in electricity and heavy industrial output under the impact of the global economic slowdown and a temporary domestic crackdown on real estate investment prior to the implementation of the massive Chinese domestic economic stimulus plan of 2009-2010.

As shown in **Table 10** and **Figure 15** below, electric power generation has been the most significant driver for coal consumption in Henan, with steel, cement, and coal-based chemical industry accounting for most of the remainder. The province installed 30,000 MW of coal-based generating capacity from 2006-2010 (21,000 net after subtracting retired units), which translates into approximately 55-60 million tons of additional coal consumption (People's Daily Net, 2010).

**TABLE 10: COAL CONSUMPTION BY END USER, 2005-2009 (MILLION TONS)**

| | 2005 | 2007 | 2009 |
|---|---|---|---|
| Thermal Power | 77.7 | 94.5 | 94.0 |
| Coking | 19.4 | 29.2 | 29.0 |
| Loss in coal washing | 5.6 | 8.5 | 15.2 |
| Industry | 61.8 | 76.4 | 81.9 |
| Residential | 12.2 | 11.0 | 10.7 |
| Other | 8.0 | 12.1 | 13.7 |
| Total | 184.7 | 231.7 | 244.5 |

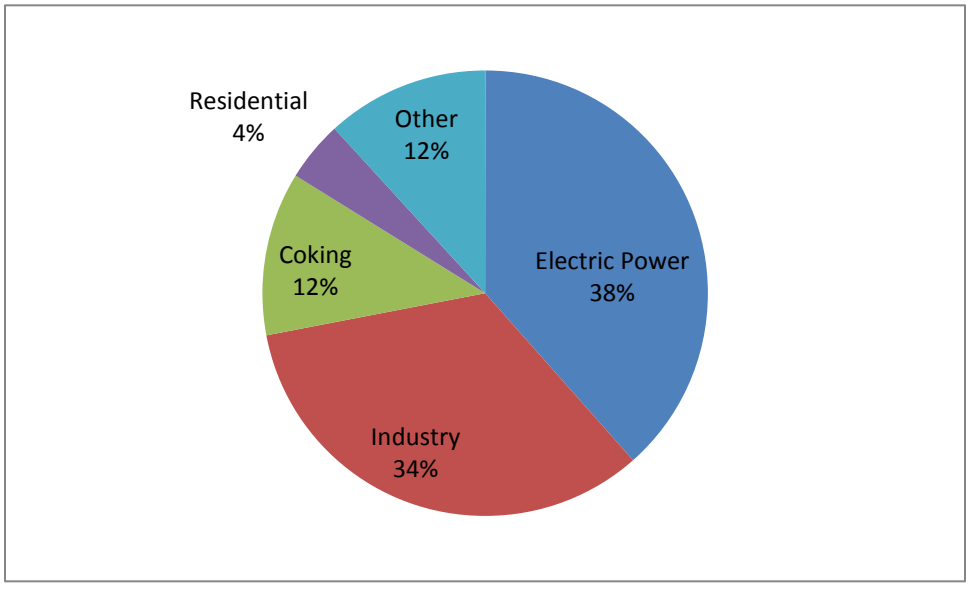



**FIGURE 15: HENAN COAL CONSUMPTION BY END USER: 2009. SOURCE: CESY 2010, P. 182**

It is clear from **Table 10**, however, that the actual increase in power plant coal consumption was considerably lower. This is a direct consequence of the replacement of smaller, less efficient units with

600 MW supercritical generating units and, starting from 2010, with 1000 MW super-supercritical units of 42 percent energy conversion efficiency. According to the Deputy Governor of Henan, coal consumption per kwh dropped by 16 percent from 2006-2010 (People's Daily Net, 2010).

Over the longer term, growth in coal demand in Henan may moderate somewhat as the national economy gradually becomes more consumption and less investment driven but the importance of Henan's coal-based power to a Central China power grid that is significantly hydro-based in other areas will likely ensure continued growth in coal-fired electricity generation of at least 8 percent per year order of magnitude for the immediate future. Four 1000 MW super-supercritical units are already under construction, and a number of others are in the planning stage, including several located near the Hebi mines (NDRC, 2011.1; Tianya, 2010; Sanmenxia, 2011; SDIC, 2009). Efficiency improvements will continue to reduce coal consumption per unit of output for a period of time, but, barring economic shock, coal consumption increases from all Henan consumers of 6-8 percent seems reasonable for the medium-term future.

*Demand Outside of Henan*

Henan has traditionally been a shipper of coal to neighboring, coal-deficient provinces to the south such as Hunan and Hubei, as well as to coastal provinces such as Jiangsu, Shanghai, and Zhejiang. As noted above its ability to maintain these shipments has declined substantially in 2010-2011. But even under these conditions, the Pingdingshan company will continue to ship tens of millions of tons of coking coal per year to steel users outside the province, and some steaming coal will be sold to coal-deficient provinces to the south and east. In the unlikely event that coal production in Henan grows faster than provincial demand, outside buyers will almost certainly prove capable of consuming the excess.

*Demand for Hebi Coal*

Hebi's low volatile bituminous coal is suitable primarily for power plant and industrial use, with some output from its washing plant also injected into steel mill blast furnaces. An 1800 MW mine-mouth power plant partly owned by Hebi Mining Group consumes 4 – 4.5 million tons per year. An additional 4100 MW of coal-fired generating capacity are located within 60 km of Hebi, and thousands of additional megawatts of capacity are in various stages of planning.

The mine supplies a reported 30 percent of the requirements of two of these plants with 1200 MW capacity located in Anyang City, a sign that it strives to maintain a diverse customer base rather than selling only to plants in the immediate vicinity. Like other large state-owned mines, it strives to maintain a balance between sales to traditional large customers under one-year contracts, and spot sales to customers of all kinds, which allow it to take advantage of surges in spot market prices such as the one taking place in 2011.

### 3.2.4 Guizhou

Guizhou is a mountainous province located in southwestern China. Guizhou Province is shown in **Figure 16**.

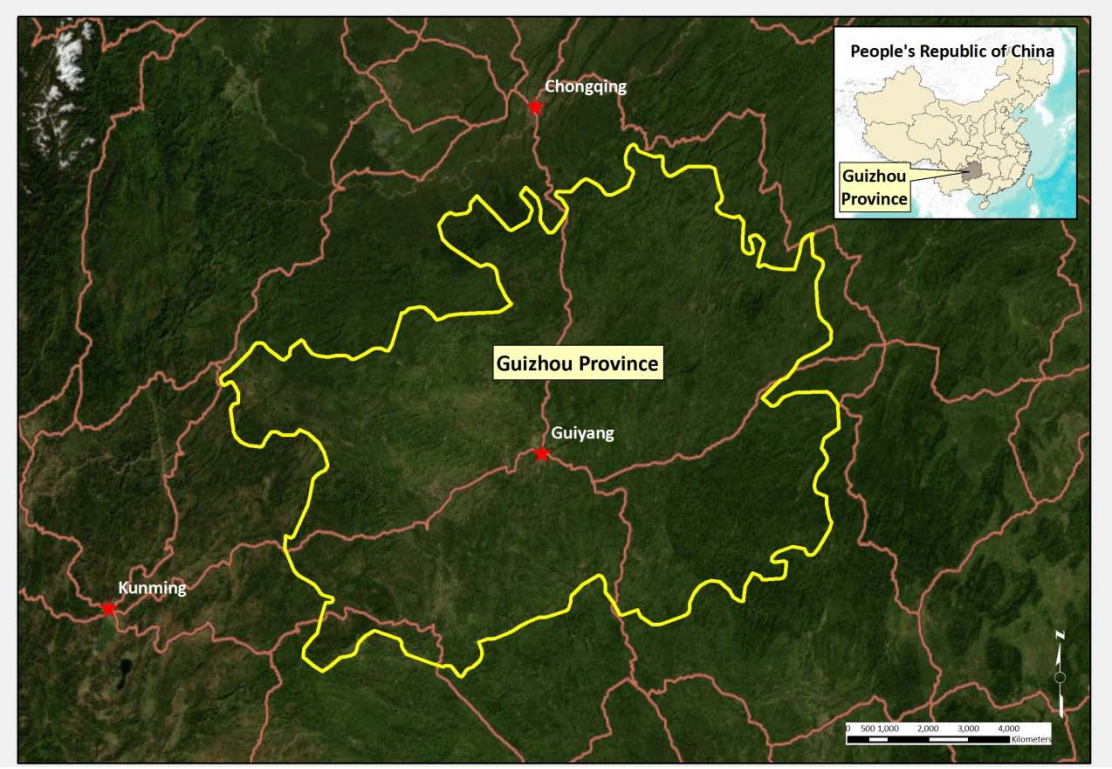



**FIGURE 16: MAP SHOWING GUIZHOU PROVINCE**

*Supply and Demand*

Guizhou accounts for approximately 5 percent of China's coal supply and perhaps 3 percent of its demand. Supply and demand from 2005-2010 are shown below in **Table 11**.

**TABLE 11: GUIZHOU COAL SUPPLY AND DEMAND (MILLION TONS)**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Production | 108.0 | 118.2 | 108.6 | 118.0 | 136.9 | 159.5 |
| Consumption | 86.5 | 99.4 | 106.6 | 97.3 | 109.1 | 119 |
| Out of Province Sales | 31.5 | | 26.9 | | 27.5 | 40 |

Source: CESY 2010, pp. 35, 83, 214; CESY, 2008, p. 214; CESY, 2006, p. 218; GSB, 2011; Guizhou Government Website, 2011

Guizhou has traditionally been a coal exporting province, shipping 25-30 million tons to outside customers in recent years. The Panzhihua Steel Mill in neighboring Sichuan Province is a major designated customer, consuming approximately 2.5 million tons of Guizhou coking coal, with most of the remaining shipments outside the province consisting of raw steaming coal sold in small lots to utilities and industrial facilities in Hunan, Chongqing, Sichuan and Guangxi. In addition to growth of

consumption inside the province, rail transport bottlenecks have limited the volume of shipments outside the province (Gang123, 2009; Okuno, 2006).

Electric power, which accounts for close to half of Guizhou's coal consumption, with other industrial uses such as aluminum, chemical fertilizer feedstock, and coking accounting for most of the remainder. Residential consumption has declined steadily as urban residents have been hooked to the coal gas network, and now constitutes an insignificant percentage of the total.

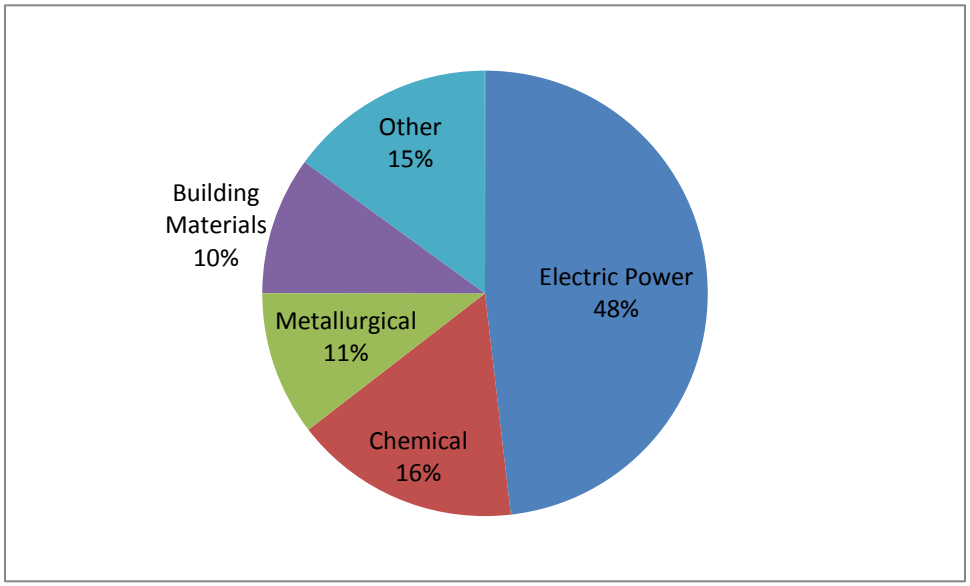



**FIGURE 17: GUIZHOU COAL CONSUMPTION, 2010, SOURCE: GUIZHOU GOVERNMENT 2011**

The Guizhou Coal Bureau has projected in-province demand growth at 11.5 percent per year from 2010-2015 to approximately 170 million tons, driven largely by the electric power plant construction program discussed in **Section 4.4.2**. The Bureau estimates that power plant demand will jump to as much as 58 percent of the provincial total by that time (Guizhou Government, 2011).

Based on known mine development plans, the Guizhou Coal Bureau targets provincial coal production to reach approximately 210 million tons in 2015, allowing for approximately 40 million tons of shipments outside the province. Even if in-province demand grows at a somewhat lower rate than the Bureau's projections, chronic coal shortages in the southern and western provinces surrounding Guizhou such as Guangdong, Sichuan and Chongqing, Hunan, and Yunnan, should ensure sufficient demand for all coal produced in the province assuming transport capacity is commensurately increased. The proximity of Guizhou to these provinces makes its coal cost competitive with alternative sources in North China.

Guizhou's coal quality also makes it relatively attractive to neighboring provinces, especially vis-a-vis other southern and southwestern Chinese coals, much of which are high sulfur anthracite. Much of Guizhou's coal, by contrast is low-sulfur bituminous coal or semi-anthracite, and the province is virtually the only source of coking coal in south and southwest China.

*Production*

The Guizhou coal industry is spearheaded by three large, modernized provincially owned companies established in the 1960s with current aggregate production of approximately 20 million tons which typically sell under one-year contracts to their larger consumers: Shuicheng (10-11 million tons); Panjiang (13 million tons); and Liuzhi (3-4 million tons) (Guizhou Government, 2011). Remaining production, which now totals over 100 million tons, has traditionally come from hundreds of smaller, less mechanized mines owned at the sub-provincial level which sell under spot contracts. The quality of these coals, in particular their ash content, is also uneven compared to the larger mines (Guizhou Daily, 2010; Shuicheng Mining Group Website).

The central government's drive to consolidate these smaller mines to a capacity level of at least 300,000 tons and to close the most dangerous and least efficient undoubtedly accounts for the temporary slump in production in 2007-2008 (**Table 11** above). The provincial and central governments are also making a concerted drive to introduce larger, better funded, and better managed investors to take the lead in new mine development. In addition to the three in-province majors, these include companies such as the Shandong Yanzhou Coal Mining Group, which is developing a series of mines with aggregate capacity of over 12 million tons, as well as major utility coal consumers such as Nengfa's parent company China Power Investment.

# 4. Electricity Market

## 4.1 National Electricity Market

### 4.1.1 Supply and Demand Overview

Electricity production and generation capacity in China increased at robust rates of 14.4 and 15.3 percent, respectively, from 2003-2007, considerably in excess of average economic growth of around 10 percent during the same period. Total generating capacity increased by a staggering two hundred thousand megawatts during 2006 and 2007.

The growth has come primarily from thermal power plants (overwhelmingly coal-fired) which have consistently accounted for about 82 percent of electrical output (**Table 12** and **Table 13**). Despite the construction of a number of large hydro projects, the hydro percentage of total output has remained at a level of about 15-16 percent. Nuclear has accounted for virtually all the remaining 2-3 percent of output, a percentage that is likely to increase over the coming 5-10 years. While China is beginning to construct large numbers of wind power plants, their output is not yet a significant component of the overall power mix. The torrid growth in generation capacity, which represented the completion of projects begun several years earlier, continued through 2008. Starting from June 2008, however, monthly output growth dropped into single digits, as shown below in **Figure 18**. In October, as the world economic downturn accelerated, China recorded negative electricity growth for the first time in memory; November 2008 output was 9.6 percent lower than November 2007 (NBSC, 2008).

**TABLE 12: CHINA ELECTRICITY GROWTH, 2000 - 2004**

| | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|
| Electricity Output (TWh)<br>*Growth* | 1,355.6 | 1,480.8<br>*9.2%* | 1,654.0<br>*11.7%* | 1,910.6<br>*15.5%* | 2,203.3<br>*15.3%* |
| Thermal<br>*Growth* | 1,114.2 | 1,183.4<br>*6.2%* | 1,338.1<br>*13.1%* | 1,580.4<br>*18.1%* | 1,795.6<br>*13.6%* |
| Hydro<br>*Growth* | 222.4 | 277.4<br>24.7% | 287.9<br>*3.8%* | 283.7<br>*9.9%* | 353.5<br>*24.6%* |
| Nuclear<br>*Growth* | 16.7 | 17.5<br>*4.3%* | 25.1<br>*4.4%* | 43.3<br>*7.2%* | 50.5<br>*16.5%* |
| | | | | | |
| Electricity Capacity (MW)<br>*Growth* | NA | NA | NA | 403,353 | 453,903<br>*12.5%* |

**TABLE 13: CHINA ELECTRICITY GROWTH, 2005 -2010**

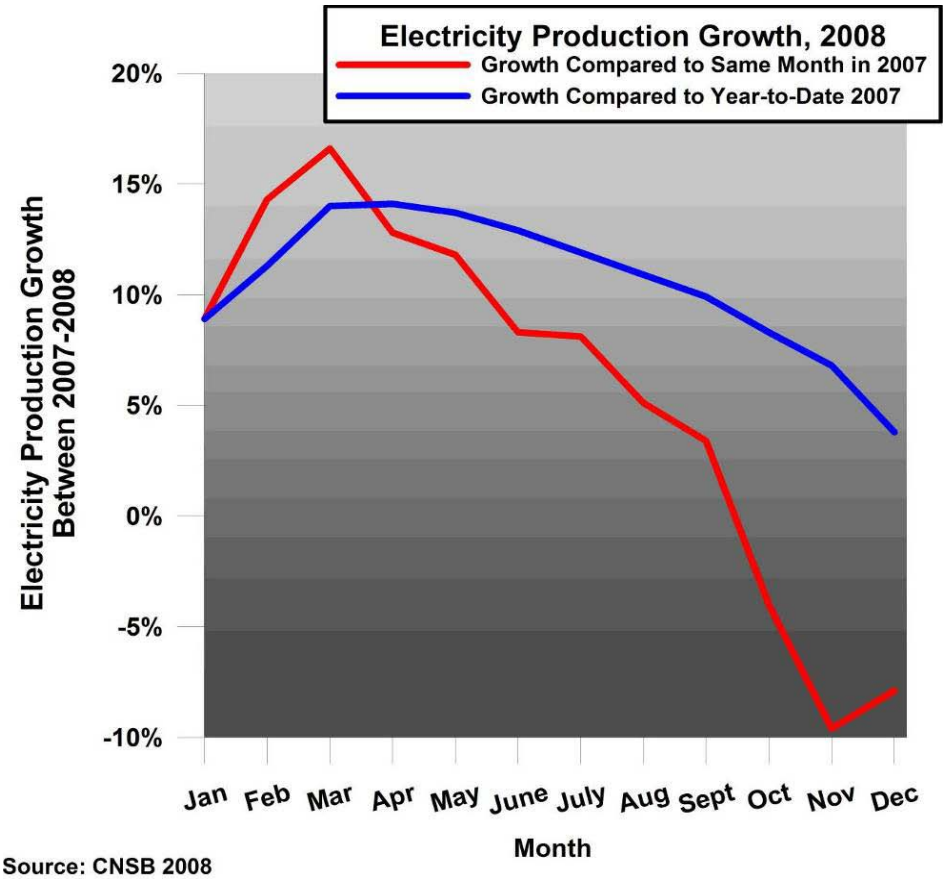
| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Electricity Output (TWh) | 2,500.3 | 2,865.7 | 3,281.6 | 3,466.9 | 3,715.7 | 4,206.5 |
| *Growth* | *13.5%* | *14.6%* | *14.5%* | *5.6%* | *7.1%* | *13.2%* |
| Thermal | 2,047.3 | 2,369.6 | 2,722.9 | 2,790.1 | 2,982.8 | 3,330.1 |
| *Growth* | *14.0%* | *15.7%* | *14.9%* | *2.5%* | *6.9%* | *11.7%* |
| Hydro | 397.0 | 435.8 | 485.3 | 585.2 | 615.6 | 721.0 |
| *Growth* | *12.3%* | *9.7%* | *11.4%* | *20.6%* | *5.2%* | *17.1%* |
| Nuclear | 53.1 | 54.8 | 62.1 | 68.4 | 70.1 | 73.9 |
| *Growth* | *5.2%* | *3.2%* | *13.3%* | *10.1%* | *2.5%* | *5.3%* |
| | | | | | | |
| Electricity Capacity (MW) | 517,163 | 623,698 | 713,261 | 803,771 | 874,000 | 962,190 |
| *Growth* | *13.9%* | *20.6%* | *14.4%* | 12.7% | *8.7%* | *10.1%* |

Sources: CESY (2008, 2010), p. 75; NBSC (2008); NBSC (2007.1), Table 5, NBSC (2008.1), Table 5; CEPY (2007, p. 625)

**TABLE 14: ELECTRICITY PRODUCTION GROWTH, 2008**

| | Growth compared to same month 2007 | Growth compared to year-to-date 2007 |
|---|---|---|
| January | 8.9% | 8.9% |
| February | 14.3% | 11.3% |
| March | 16.6% | 14.0% |
| April | 12.8% | 14.1% |
| May | 11.8% | 13.7% |
| June | 8.3% | 12.9% |
| July | 8.1% | 11.9% |
| August | 5.1% | 10.9% |
| September | 3.4% | 9.9% |
| October | -4.0% | 8.3% |
| November | -9.6% | 6.8% |
| December | -7.9% | 3.8% |

Source: CNSB (2008)




Source: CNSB 2008

**FIGURE 18: ELECTRICITY PRODUCTION GROWTH**

Industry accounts for approximately 75 percent of electricity consumption (CESY 2007, p. 20). The electricity consumption decline between November 2008 and November 2007 was driven by steeply falling output of energy-intensive industrial products, such as steel, by far the largest industrial consumer of electricity (-12.4 percent); non-ferrous metals (-4.3 percent); key industrial chemicals including soda ash (-21.8 percent), caustic soda (20.6 percent), and sulfuric acid (-26.2 percent).

The World Bank projected that China's economy as a whole would grow by approximately 7.5 percent in 2009, with as much as half of this growth coming from the implementation of the government's announced 4 trillion RMB economic stimulus package 2009-2010 (WB, 2008). As this package was to be centered on government investment in infrastructure directly related to people's livelihood – such as public housing, transport, urban environmental protection including sewage and pollution treatment, earthquake reconstruction, and power grids – some recovery in output of electricity-intensive industrial products such as steel was expected.

But it was questionable as of year-end 2008 whether national demand for electric power would grow as quickly in the next five years as it did in the 2001-2008 period. At the least, it would take time for the investment environment to recapture the go-go atmosphere of the 2001-2007 period; the Chinese government itself hoped to use the downturn of 2008 to recalibrate growth along a more sustainable, less energy-intensive path, and it is conceivable that the least energy efficient steel, cement plants, etc. will be closed during the immediate period of slower growth. Civil and commercial consumption of

power is expected to grow rapidly as urbanization accelerates – but as these sectors only accounted in late 2008 for approximately 14 percent of total electricity consumption, (CESY, 2008, p. 107) they cannot be expected to completely substitute for slower growth in electricity-intensive industry.

Given the rapid construction of electricity generation capacity since 2003, including many projects still outstanding, there is a distinct possibility that power generation capacity will outstrip demand in many parts of the country by 2012-2014. The appetite for new power construction will likely decrease correspondingly, and dispatch of existing plants – particularly coal-fired power plants – will decrease.

### 4.1.2 Changes in National Patterns of Economic and Electricity Consumption Growth

During the sustained boom fueled by exports and domestic capital investment between 2000 and 2007 (**Figure 19**), China's electricity consumption grew by an average of 13.5 percent, a full 30 percent higher than overall economic growth (CESY 2008 Table 1-1). The surge in production of iron and steel (21 percent growth), non-ferrous (17 percent growth) and other energy intensive raw materials used in capital investment projects was the major reason for this differential. Led by these commodities, industry's share rose from 71.7 percent of total electricity consumption in 2000 to 75.3 percent in 2007 (CESY, 2008, Table 5-13).

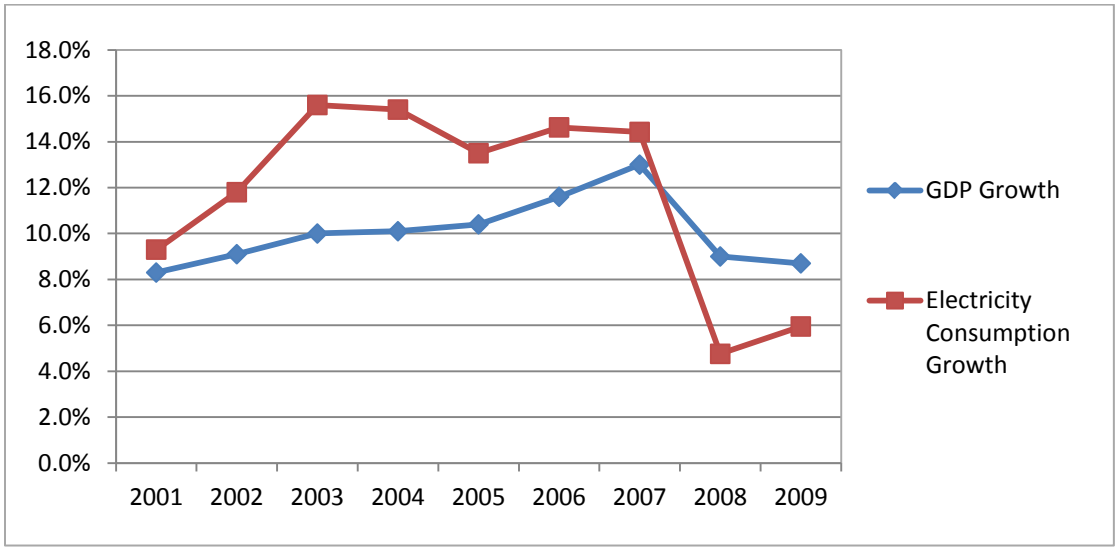



**FIGURE 19: CHINA: ECONOMIC GROWTH AND ELECTRICITY CONSUMPTION GROWTH, 2000-2009. SOURCES: CESY 2008 TABLES 1-1 AND 5-13, NBSC 2009, NBSC 2010, NDRC 2010.1**

Patterns of growth changed abruptly under the impact of the global economic slowdown in the second half of 2008, carrying through into the first half of 2009 (**Figure 19**). Year-on-year economic growth decelerated to a low of 6.1 percent in the first quarter of 2009. As new investment spending and factory orders for steel and other electricity intensive commodities dried up, electricity consumption declined in absolute terms during both fourth quarter 2008 and first quarter 2009.

The government's four trillion RMB (approximately $600 billion) infrastructure investment stimulus program gradually revived both the economy as a whole and electricity consumption starting from the

second half of 2009. Just as electricity consumption had fallen more drastically than the economy as a whole, it rose more rapidly after the stimulus kicked in as orders for steel and other energy-intensive products rebounded (**Figure 20**).

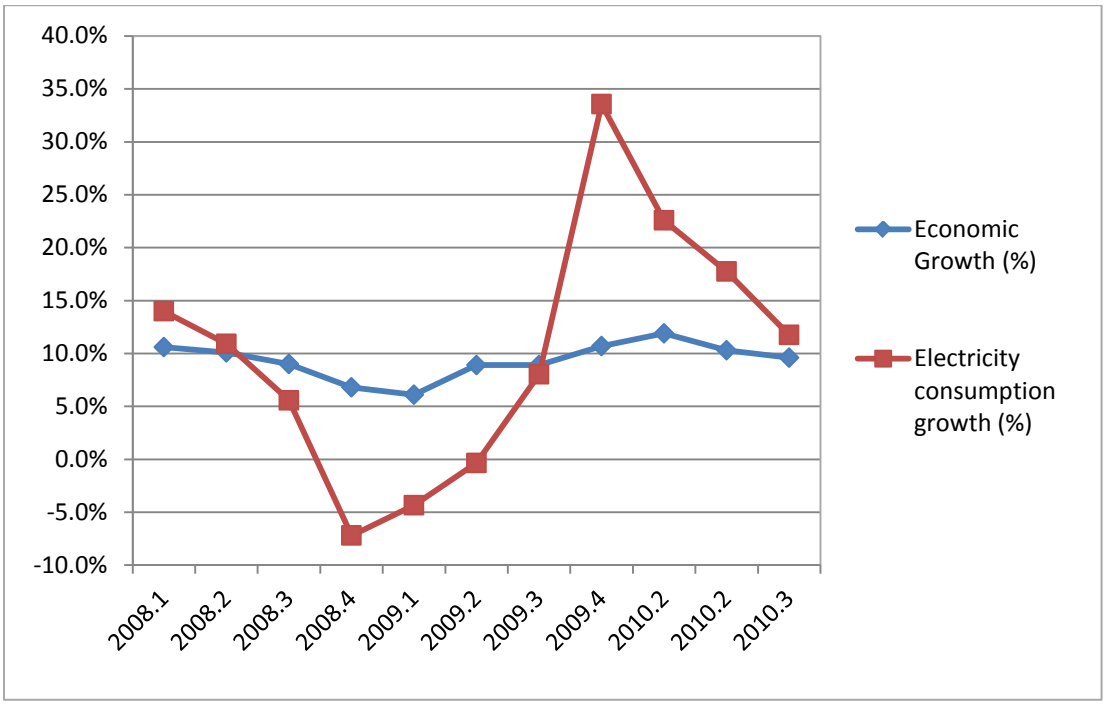



**FIGURE 20: CHINA: YEAR ON YEAR QUARTERLY ECONOMIC AND ELECTRICITY CONSUMPTION GROWTH, 2008 – 2010. SOURCES: NBSC 2009 AND 2010, NBSC MONTHLY 2008-2010, NBSC QUARTERLY 2010**

The two curves even out considerably, however, when compounded two-year growth is calculated for the period of recovery starting from third quarter 2009 (**Figure 21**). For the first three quarters of 2010, in fact, average two-year compounded growth for the economy as whole and for electricity were virtually identical at 9.1 and 8.83 percent, respectively.

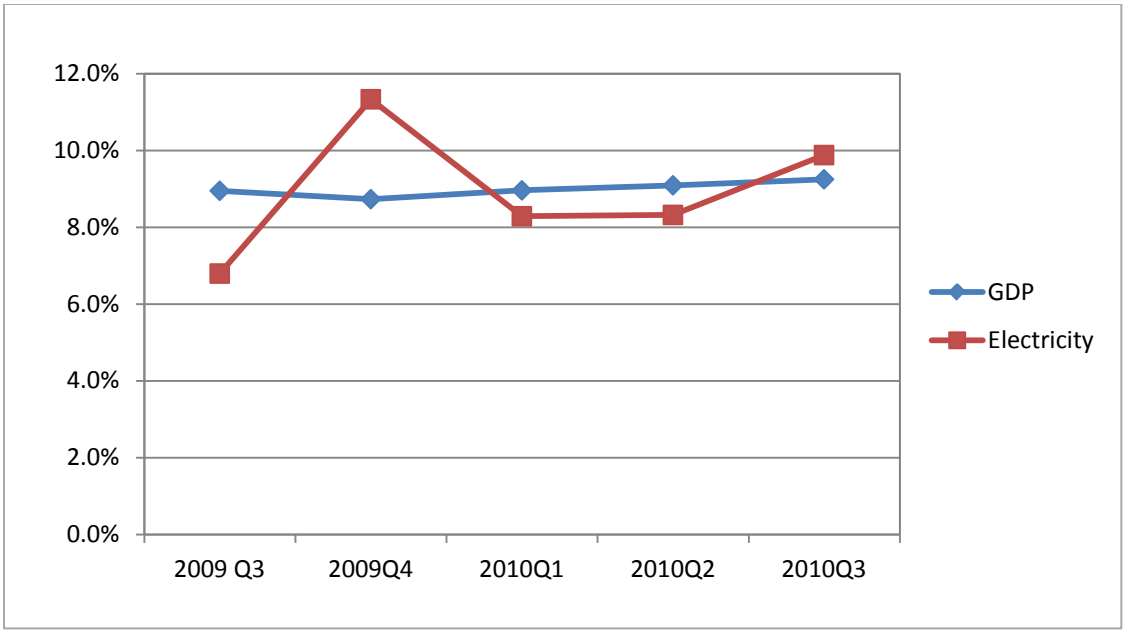



**FIGURE 21: CHINA: YEAR ON YEAR QUARTERLY ECONOMIC AND ELECTRICITY CONSUMPTION GROWTH, 2008 – 2010. SOURCES: NBSC 2009 AND 2010, NBSC MONTHLY 2008-2010, NBSC QUARTERLY 2010**

As the stimulus program winds down, the trends reflected in these two year compounded numbers – economic growth in the eight to ten percent per year range and electricity consumption growth at a ratio of approximately 1:1 compared to the period from 2000 through 2007 – could persist into the medium-term future. Reputable international organizations such as the World Bank are in fact already predicting that overall economic growth will fall in this range after 2010 (World Bank, 2010).

While the Chinese government has not as yet published the growth targets for the twelfth five-year plan covering the years 2011 through 2015, all its public comments reflect a desire to alter the country's growth trajectory from one dominated by investment to one more heavily weighted towards growth in consumption and standards of living in all areas of the country. It has furthermore made clear its concerns to control real estate investment, which rebounded strongly starting from the second half of 2009. All of these measures would have the effect of moderating electricity consumption growth.

### 4.1.3 Electricity Grid

China has long struggled with the problem of most of its power generation facilities, both coal fired and hydroelectric, being located in the north and west of the country, while greater than 75 percent of energy demand comes from the heavily industrialized and densely populated central and eastern regions. A lack of reliable transmission capability has led to frequent supply disruptions in the major energy consuming regions.

A state monopoly, the State Power Corporation (SPC), ran all sectors of China's national electricity system until 2002, when it was dismantled by the government and several new companies were created to run the generation sector and the transmission and distribution sector as separate entities. Electricity and transmission assets were split between seven regional and five provincial electricity grids (**Figure 22**)

controlled by two companies, the Southern Power Company and the State Power Grid Company. Overall regulation of the electricity sector is the responsibility of the State Electricity Regulatory Commission (SERC), also established in 2002, to oversee the newly formed generation and distribution companies.

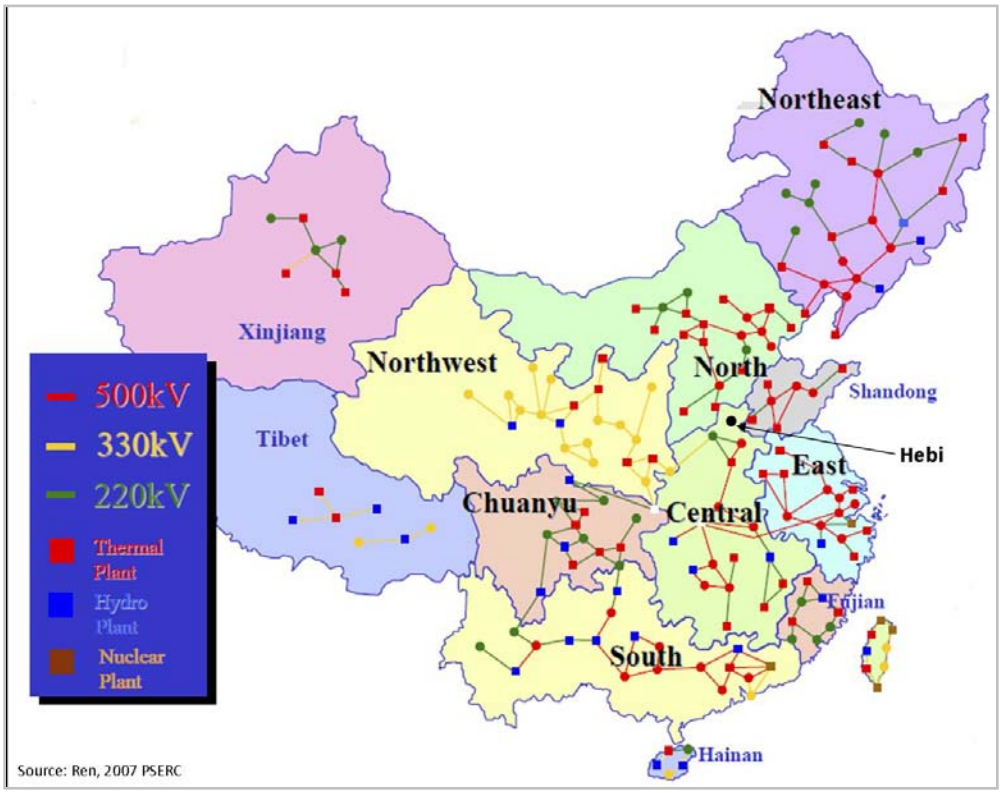



**FIGURE 22: POWER NETWORK IN CHINA**

While some market competition has been allowed in the generation sector, the transmission and distribution networks continue to be heavily state-controlled, with the government providing blueprints for the development of the national electricity grid for the next ten years. Plans include the merging of the twelve separate grids into three large power grid networks by 2020 (EIA, 2009), with the smaller grids linked by new, high voltage transmission lines. In January of 2009, the first such ultra high voltage (UHV) line became operational between Shanxi Province and Hubei Province. Designed to transmit power over long distances, without the transmission losses associated with the more common 500kv lines, the 640 km long, 1,000 kv line joins the North China power grid with the Central grid for the first time. Three major west-to-east transmission corridors are also planned (North, Central and South), with the capacity of each corridor reaching 20 GW by 2020, all with the aim of alleviating supply problems between western generators and eastern consumers.

### 4.1.4 Electricity Price

China's electricity prices are complex and still mostly regulated by the government. There are three general price categories: the wholesale price, the transmission and distribution price, and the retail price. The wholesale and transmission/distribution prices are approved by NDRC, whereas the retail price is set by NDRC. The pricing system for wholesale power is based on a "cost plus profit" approach and a "same grid, same price" principle (Ni, 2007). The NDRC determines both the price at which generating companies can sell power to the grid and what prices the grid operators can charge different categories of users. These prices are set on a province by province basis, in consultation with local price bureaus. The NDRC attempts to balance affordable prices for industrial and residential customers with the need for generation and grid companies to make enough profit to finance future power plants and transmission networks. Electricity rates currently favor industrial customers and can be 40 percent lower than other retail customers (EIA, 2009). Residential customers pay between RMB 0.52-0.56 per kWh (7-8 cents/kWh) in the region while industrial users pay RMB 0.33-0.49 per kWh (5-7 cents/kWh). Hardest hit are commercial customers who pay RMB 0.73-0.80 per kWh (11-12 cents/kWh). Grid companies buy electricity from power companies at a cost of approximately RMB 0.3-0.4 per kWh (4-6 cents/kWh).

China's electricity market is complicated by the government trying to control prices to end users, while the price of coal, the major fuel source for power generation, is subject to market forces. In times of large thermal demand, power generators have lost money as the price of coal rose and increased costs could not be passed on to consumers. In some cases this has resulted in power stations shutting down and exacerbating supply problems. In response to such price imbalances, NDRC is working to reform the electricity pricing structure to allow more market influence. These reforms are expected to lead to higher electricity prices for all users in the near future.

Since 2002, a uniform wholesale price for similar types of power plants has been introduced with the aim of reducing the high overall cost. This pricing system does not take into account efficiency and environmental performance even among the same types of power plants.

A coal-fired power price adjustment mechanism was introduced in May 2006, allowing power generators to pass on coal price hikes within their wholesale rate at a cap of 8 percent per year. Only about 70 percent of any increase in coal price can be added to the wholesale price for coal-fired power plants, while the remaining 30 percent must be absorbed. The mechanism applies only to coal prices, not to natural gas fuel prices. Given that the government intends to raise the price for natural gas by 8 percent per year, gas-fired power generators will have more difficulties competing with coal-fired generators and operating their plants if any increases in gas fuel cannot be included into their wholesale power prices.

To promote the installation of flue-gas desulphurization (FGD) equipment, which reduces $SO_2$ pollution, an environment premium has been set at 0.015 RMB per kWh for qualifying coal-fired power plants. However, there are no environmental premiums or taxation preferential policies for gas-fired power plants.

**Table 15** shows the wholesale power price for thermal coal-fired power plants in China.

**TABLE 15: WHOLESALE POWER PRICE FOR THERMAL COAL-FIRED POWER PLANTS IN CHINA**

| Region | Province | Wholesale Price (RMB/kWh) | | | |
|---|---|---|---|---|---|
| | | Thermal | | | |
| | | Coal-fired power plants | | Gas-fired power plants | Hydro |
| | | With FGD | Without FGD | | |
| North China | Beijing | 0.320 | 0.305 | | |
| | Tianjin | 0.320 | 0.305 | | |
| | Hebei | 0.320 | 0.305 | | |
| | Shanxi | 0.250 | 0.235 | | |
| | Shangdong | 0.325 | 0.310 | | |
| | Inner Mongolia | 0.252 | 0.237 | | |
| East China | Shanghai | 0.390 | 0.375 | | |
| | Jiangsu | 0.370 | 0.355 | | |
| | Zheijiang | 0.400 | 0.385 | | |
| | Anhui | 0.345 | 0.330 | | |
| | Fujian | 0.365 | 0.350 | | |
| Central China | Hubei | 0.335 | 0.320 | | |
| | Hunan | 0.360 | 0.345 | | 0.315 |
| | Jiangxi | 0.350 | 0.335 | | |
| | Henan | 0.305 | 0.290 | | |
| | Sichuan | 0.310 | 0.295 | | 0.280 |
| | Chongqing | 0.310 | 0.295 | | |
| South China | Guangdong | 0.420 | 0.405 | | |
| | Guangxi | 0.335 | 0.320 | | 0.260 |
| | Yunnan | 0.255 | 0.240 | | 0.215 |
| | Guizhou | 0.250 | 0.235 | | 0.215 |
| | Hainan | 0.365 | 0.350 | 0.350 | 0.260 |

Source: Ni, 2007

### 4.1.5 Electricity Policies

CMM has been captured and used in China as far back as 1952, when CMM from the Fushun Mine in Liaoning Province was used as the raw material for a carbon black plant. However, it wasn't until 1982 that the Chinese government formally recognized CMM's potential as a power source and CMM utilization was added to the national investment plans of capital construction and energy conservation (CBMC, 2004). The Fushun mine went on to build China's first demonstration CMM power plant (1,500 kW) in 1990 and added a second plant (2 x 2,000 kW) in 2002.

In 2007, in a bid to accelerate the development of power projects fueled by CMM, NDRC issued new requirements covering the generation of electricity by CMM/CBM projects (IEA, 2009). Specifically, CMM generated electricity is to be given priority by grid operators, who should purchase the electricity at an NDRC specified, subsidized price. The requirements also promote CMM power generation facilities larger than 500 kW per unit, by making such projects exempt from paying the connection fee normally charged to small scale coal fired plants, and exempt plant operators from market price competition,

while minimizing their responsibilities to providing grid stability. In practice, electricity distribution companies do not find it profitable to use the more expensive, subsidized CMM generated power, and have tried to make up lost revenue by charging additional fees for use of the power distribution grid. This in turn makes the economics of CMM electricity generation for sale to the grid unattractive for mine operators. Provincial representatives of NDRC appear to have little authority to enforce the nationally mandated CMM power subsidy and access policies and as a result, these policies have had limited implementation (IEA, 2009).

### 4.1.6 Market for CMM Fueled Power Generation

The first major use of CMM for electricity generation was at the Appin and Tower Coal mines near Sydney, Australia. In 1996, a total of 94 individual 1 MW spark-ignited reciprocating gas engines were installed in two CMM power generation plants (with total capacity of 94 MW). Since that time, China has adopted CMM power generation technology widely and used CMM for generating electricity at many of its mine sites, its most notable success being at the Sihe Mine in Shanxi Province, where the world's largest CMM-to-power generation facility (with a capacity of 120 MW) is installed. At most mine sites, however, generation facilities are generally in the 0.5-2 MW range and electricity is generated solely for use at the mine site.

Power generation from CMM is becoming increasingly important in China. IEA (2009) reports that in 2005, 2.3 billion cubic meters of methane was drained; 1.0 billion cubic meters was used; and power generation capacity (including plants installed and under construction) reached 200 MW. By 2006, these figures became 3.0 billion cubic meters, 1.2 billion cubic meters, and 460 MW. According to the latest five-year plan, China will drain 5 billion cubic meters of coal mine methane and utilize 60 percent of this gas by 2010. This figure may be conservative as 4.7 billion cubic meters of CMM was drained in 2007, with more than 2 billion cubic meters drained from Shanxi Province alone. Henan province recovered about 0.2 billion cubic meters.

## 4.2 Anhui/East China Grid

### 4.2.1 Anhui Electricity Supply Demand, Organizational Structure, Dispatch and Pricing

*Anhui's Power Industry in a Regional Context*

Anhui, Shanghai, Zhejiang, and Jiangsu provinces comprise the core of the East China Power Grid (ECPG) subject to the management of the East China Power Grid Company. Fujian Province, while nominally a member of the ECPG, is far less integrated with the other four provinces than they are with each other; Fujian's generation and consumption have been essentially balanced over the last five years with little electricity either into or out of the provinces (**Table 16**).

**TABLE 16: ELECTRICITY PRODUCTION AND CONSUMPTION IN THE EAST CHINA POWER GRID, 2005-2010**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Anhui | | | | | | |
| -- Production | 64.81 | 73.49 | 87.34 | 117.01 | 132.10 | 144.39 |

| | | | | | | |
|---|---|---|---|---|---|---|
| -- Consumption | 58.17 | 66.24 | 76.87 | 85.89 | 95.23 | 107.79 |
| -- Surplus/Deficit | 6.65 | 7.25 | 10.47 | 31.12 | 36.87 | 36.60 |
| Jiangsu | | | | | | |
| -- Production | 212.00 | 253.55 | 267.46 | 290.20 | 298.32 | 349.93 |
| -- Consumption | 219.35 | 256.98 | 295.20 | 311.83 | 331.40 | 386.44 |
| -- Surplus/Deficit | -7.35 | -3.42 | -27.74 | -21.64 | -33.08 | -36.51 |
| Shanghai | | | | | | |
| -- Production | 73.40 | 72.07 | 73.91 | 77.36 | 76.72 | 87.62 |
| -- Consumption | 92.20 | 99.02 | 107.24 | 113.82 | 115.34 | 129.59 |
| -- Surplus/Deficit | -18.80 | -26.94 | -33.32 | -36.47 | -27.72 | -41.97 |
| Zhejiang | | | | | | |
| -- Production | 145.64 | 176.64 | 191.52 | 207.31 | 218.96 | 249.62 |
| -- Consumption | 164.23 | 190.92 | 218.93 | 232.29 | 247.14 | 282.10 |
| -- Surplus/Deficit | -18.59 | -14.29 | -27.42 | -24.98 | -28.18 | -32.48 |
| Fujian | | | | | | |
| -- Production | 77.83 | 90.43 | 103.83 | 10.85 | 117.30 | 135.63 |
| -- Consumption | 75.66 | 86.68 | 100.03 | 10.73 | 113.50 | NA |
| -- Surplus/Deficit | 2.17 | 3.74 | 3.80 | 0.12 | 3.80 | |
| Shanghai, Zhejiang, Jiangsu aggregate | | | | | | |
| -- Production | 431.04 | 502.26 | 532.89 | 574.86 | 594.01 | 687.17 |
| -- Consumption | 475.77 | 546.91 | 621.37 | 657.94 | 693.88 | 798.12 |
| -- Surplus/Deficit | -44.74 | -44.65 | -88.48 | -83.08 | -99.87 | -110.96 |

Source: CESY, 2011, pp. 43, 91, 156, 160, 164, 168; SSA, 2010; Anhui Daily, 2011; Shanghai, Jiangsu, Zhejiang Statistical Bureau, 2011

Zhejiang, Shanghai, and Jiangsu are the economic powerhouse coastal provinces of the Yangtze River delta whose economy modernized and urbanized rapidly starting from the 1980s and 1990s. They developed a large electricity generation base composed primarily of thermal power plants burning coal shipped from the north that was sufficient to satisfy their needs through approximately 2002-2003.

Anhui is an interior, more rural province whose economy modernized more slowly. As it is also by far the largest coal producer in the East China region, regional and national planning authorities developed the so-called “Anhui power to the East” program in the mid 2000s with the explicit goal of transforming Anhui into a power supplier to the three wealthier provinces under the coordination of the ECPG.

As noted above, Anhui increased its power generation capacity by nearly 150 percent from 2006-2010 to 29,300 MW with the addition of 17,200 MW of coal-fired power capacity. Seven of these plants with total capacity of 7600 MW – including the Luohe Phase III, Pingwei Phase III, Fengtai Phase I, Tianji Phase I, Bengbu, and Tianjia’an Phase II renovation located in the Huainan Region – are directly dispatched by the ECPG under the “Anhui to the East” program, with output dedicated to one or more of the three wealthy coastal provinces (ChinaPower, 2009; China Power, 2007).

In almost all cases, the Yangtze Delta provincial power companies or provincial energy investment arms have acquired an ownership stake in the power plants. Three massive 500 KV transmission lines were constructed specially by the power grid company to accommodate these plants.

As **Table 16** shows, Anhui's power exports to the Yangtze Delta provinces soared from 6.6 TWh in 2005 to almost 37 TWh in 2009 and 2010 (28 and 25 percent of Anhui's total generation) as these projects came onstream. This is the key reason why Anhui's power generation increased by an average 17.4 percent per year 2005-2010, unaffected by the economic turbulence which swept China from mid-year 2008 to mid-year 2009.

The power deficit from the three Yangtze Delta provinces rose steadily to 111 TWh in 2010, or approximately 14 percent of their total consumption, after 5 years during which growth in the provinces' consumption rose at an average rate of 10.9 percent per year, with output only growing by 9.8 percent (**Table 17**). The Three Gorges Hydropower station located outside the ECPG area appears to have played the most important role in filling in this gap. Anhui was unable to take full advantage of rising demand in the Delta due to a slowdown in commissioning of new plants, combined with rapidly rising in-province consumption.

**TABLE 17: ELECTRICITY PRODUCTION AND CONSUMPTION AVERAGE ANNUAL GROWTH, 2005 – 2010**

| | Production | Consumption |
|---|---|---|
| Anhui | 17.4% | 13.1% |
| Jiangsu | 10.5% | 12.0% |
| Shanghai | 3.6% | 7.0% |
| Zhejiang | 11.4% | 11.4% |

Source: CESY 2010, pp. 43, 80

*Anhui's Future in the East China Region*

During the first half of 2011, Zhejiang and Jiangsu Province electricity consumption rose by 11.7 and 13.6 percent respectively (ZEIA, 2011; China Central Government, 2011). If this trend continues, the gap between electricity production and consumption in the Delta provinces will increase rapidly, and Anhui will continue to be able to sell as much power into the Delta provinces as it can spare.

Even if growth in demand moderates to around 8 percent in view of a gradual macroeconomic transition from investment to consumption, there is no strong evidence to date that the Yangtze Delta provinces will add new capacity at a rate sufficient to even maintain their electricity deficit let alone narrow it. Regional and national planners seem committed to continuing to develop Anhui as a source of base-loaded coal-fired power for the entire East China Power Grid during the next five years, as reflected in the listing of a second phase of "Anhui power to the East" during the 12$^{th}$ five-year plan (2011-2015), and the ongoing construction of a 1000 KV electricity transmission line from the Huainan area to Shanghai and Zhejiang (China News Agency, 2011; Anhui Daily, 2011). Anhui is reported to have 16,000 MW of coal-fired power plants in feasibility study/design stage, approximately the same amount as was added 2006-2010 (Anhui Mayors Association, 2011).

*Pricing*

The recent wholesale power price for Anhui Province is 0.345 RMB/kWh (with FGD), which is near the off-peak price that Liuzhuang mine pays for grid power (0.36 RMB/kWh). However, during more typical periods Liuzhuang mine pays 0.57 RMB/kWh, while peak period power rates can reach as high as 0.85 RMB. The average power price during April 2009 was 0.65 RMB/kWh, during which the mine utilized 12.4 million kWh costing 8.11 million RMB.

### 4.2.2 Potential for Power Generated from CMM

Given its relatively small scale, CMM power would be dispatched by the Anhui Provincial Power Grid Company for use within the provincial grid, rather than by the ECPGC for sale to the Yangtze Delta. Strong demand for Anhui power in the Delta per the assumptions above, combined with rapid growth in Anhui provincial power demand would create the best possible circumstances for a CMM power plant at Huainan.

Anhui's power consumption grew in the 2006-2010 period at an average rate of 13.1 percent, higher than any other province within the ECPGC. As a less developed, less-urbanized province, Anhui may have more "headroom" for growth than the Delta Provinces, as both domestic and foreign investors begin to look westward.

At least for the first half of 2011, Anhui's growth in electricity consumption, at 14.2 percent, continued to outpace that of the Yangzi Delta provinces. Anhui was in fact forced to ration power to large industrial users in order to ensure fulfillment of its commitments to the Delta.

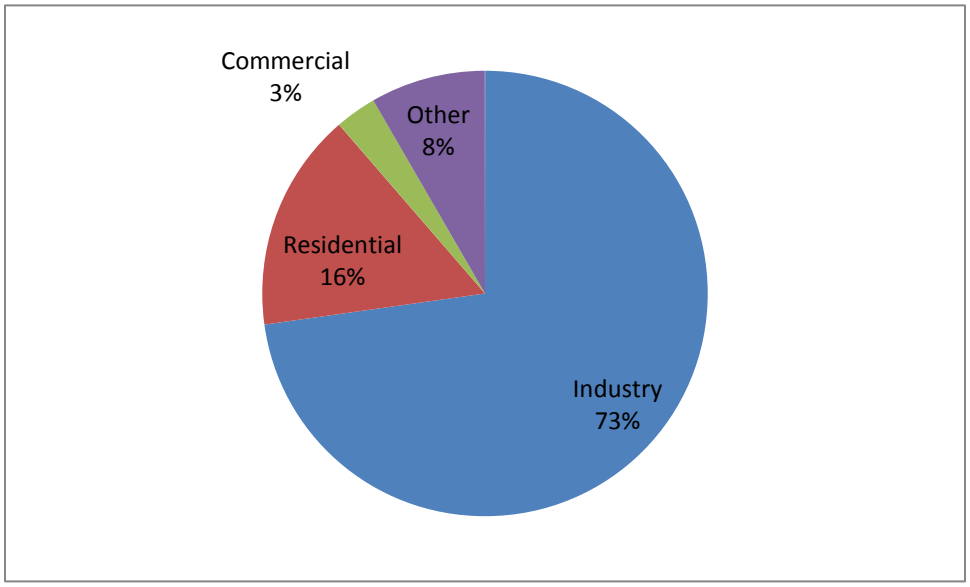



**FIGURE 23: COMPOSITION OF ELECTRICITY DEMAND IN ANHUI, 2009. SOURCE: CESY 2010, P. 168**

Industry is the major driver for electricity in Anhui (**Figure 23**), led by the Maanshan Steel Mill, whose maximum load accounts for close to 5 percent of that part of the province's generating capacity which is not dedicated to the Yangtze Delta. But residential and commercial usage actually grew at a slightly faster rate between 2007 and 2009.

## 4.3 Chongqing and Hebi/Central China Grid

### 4.3.1 Chongqing Electricity Supply Demand, Organizational Structure, Dispatch and Pricing

The Chongqing electrical distribution system is dominated by the Chongqing Power Company, a subsidiary of the Central China Grid Company which accounts for about 78 percent of total supply, with the remainder coming from small regional grids and self-owned power plants of industrial enterprises (**Table 18**). Generation facilities are owned by a combination of the five major national generating companies, the Chongqing Energy Investment Group and other local investors. While the Chongqing Power Company itself has modest peaking power generation capacity, generation and transmission/distribution are fundamentally separated under the power system reforms of 2002.

Power consumption in Chongqing grew by approximately 9.6 percent from 2002-2007, and by 13.3 percent per year from 2004 – 2007 to 44,921 GWh. Increased consumption was driven primarily by rapid growth in industrial production which accounts for 70 percent of total electricity demand, and particularly by growth in steel, non-ferrous metals, building materials, and chemicals, which account for about half of the total demand (CESY 2006, p. CESY 2008, p.117). In Chongqing as in the country as a whole, the sudden decline in production of these sectors in second-half 2008 resulting from domestic real-estate investment slowdown and the international financial crisis has depressed electricity consumption, with year-on-year electricity growth dropping by a reported 2.13 percent in October 2008, and by projected 17.9 and 10 percent respectively in November and December (CPEC, 2008.2).

The Chinese government's economic stimulus plan of 2008, with its focus on infrastructure construction, will probably bring about some rebound in demand for key industrial materials and electricity. Civil consumption of electricity will also grow as the urbanization ratio in Chongqing increases from approximately 46.4 percent in 2007 to a projected 53 percent in 2010, and possibly 70 percent by 2020. But there remains considerable uncertainty as of year-end 2008 how strong the rebound will be, and few observers predict immediate resumption of the heavy-industry and construction-driven hyper growth of previous years.

**TABLE 18: CHONGQING POWER SUPPLY AND DEMAND**

| | 2005 | 2006 | 2007 | 2008 (estimated) |
|---|---|---|---|---|
| Electricity Consumption (GWh) (+Growth) | 35,158 | 40,131 (+14.1%) | 44,707 (+11.4%) | 48,430 (+8.3%) |

| | | | | |
|---|---|---|---|---|
| Centrally dispatched | | *31,254* | *34,848 (+11.5%)* | *37,689 (+8.2%)* |
| Electricity Generation (GWh) (+Growth) | 25,390 | 28,862 (+13.6%) | 35,196 (+21.9%) | NA |
| 1. Thermal | NA | 23,460 | 29,500 | NA |
| 2. Hydro | NA | 5,300 | 5,400 | NA |
| Centrally dispatched (+Growth) | NA | *21,486* | *28,551 (+32.8%)* | *31,200 (+9.3%)* |
| Maximum Load (MW) | 7,390 | 8,350 | 9,066 (estimated) | 9,790 |
| Centrally dispatched | *5,024* | *6,115* | *6,640* | *7,170* |
| Generating Capacity (MW) | 5,678 | 7,597 | NA | NA |
| Centrally dispatched | NA | NA | *8,000* | *8,639* |
| Thermal | 3,790 | 5,594 | NA | 6,040 (central dispatch) |

Sources: Chongqing Energy Investment Corporation private communication, CQPC (2008.1, 2008.2), CESY (2008), pp. 43 - 117.

Chongqing's generation capacity grew from 5680 MW in 2005 to at least 8,639 MW in 2008 (the amount centrally dispatched – figures for capacity owned by users themselves are not available), the result of an aggressive investment program begun during the severe national power shortages in 2003. By year-end 2007 total capacity exceeded peak load for the centrally-operated grid by about 20 percent.

Nonetheless, the Chongqing grid purchased about 6,300 GWh, or approximately 18 percent of its electricity from outside of the municipality in 2007, in line with the Central China grid's policy to dispatch hydro whenever possible, due to hydro's lower wholesale power purchase cost. According to CQEIG, Chongqing imports approximately 1,000 GWh annually from the Three Gorges project at a price of 0.291 RMB per kWh as of July 1, 2008, and 4,600 GWh from the Ertan hydro station in Sichuan at 0.278 RMB per kWh (prices in effect July 2008); some off the smaller local hydro probably supply at an even lower cost (NDRC, 2008.2).

This means that thermal power plants, which constitute 70 percent of Chongqing's centrally dispatched capacity as of year-end 2008, are operating significantly below capacity. During 2006, a year of water shortage and low reservoir levels, Chongqing's thermal power plants were utilized only 5341 hours on average (CEPY, 2007, p.628). The number was undoubtedly lower than 5000 in both 2007 and 2008, when water levels were higher. The 2 x 150 MW Anwen circulating fluidized bed coal-fired power plant operated by the SCEC produced for only about 4250 hours in 2007, and was running at about half capacity during daytime hours when visited in February 2008. Given wholesale power prices of about 0.36 - 0.43 RMB per kWh for coal power (with the exception of plants that signed long-term power purchase agreements in earlier years), and 0.48 - 0.50 RMB per kWh for natural gas power compared to

hydro wholesale prices between 0.2 and 0.3 RMB per kWh, neither the Central China grid nor the Chongqing grid has incentive to dispatch thermal power plants more than necessary (NDRC, 2008.2).

In 2008, a year that power consumption in Chongqing increased by an estimated 8.4 percent, thermal power generation had only increased by 2.3 percent as of and may have registered a decline for the year as a whole (CQPC, 2008.2). Part of the reason for this was a coal price crisis that limited the ability of thermal power plants to operate in the first half of the year, but the availability of cheap hydro from in and outside of Chongqing was clearly a factor by the second half. Furthermore, in an era of uncertain growth prospects for power consumption, nearly 3,000 MW of additional power capacity are already under construction in the Chongqing, including the Shuanghuai, Shizhu, and Fengjie coal-fired plants with aggregate 2,400 MW capacity.

**TABLE 19: ELECTRICITY WHOLESALE PRICES TO CHONGQING**

| | |
|---|---|
| Three Gorges Hydro: | 0.291 RMB per kWh (delivered to Chongqing) |
| Ertan Hydro: | 0.278 RMB per kWh (delivered to Chongqing) |
| Local Coal-fired (includes flue gas desulfurization) | 0.3543 RMB per kWh (existing plants)<br>0.3793 RMB per kWh (new plants) |
| Gas-fired (Henan Province) | 0.48 RMB per kWh (to grid) |

Sources: NDRC (2008.2); NDRC (2008.3) Hubei Wuchang Natural Gas Power Plant Clean Development Mechanism Project Definition Document, Section B.5

### 4.3.2 Henan Province Electrical Market

Henan province is the sixth largest provincial consumer of electricity in China, with the adjoining provinces of Shandong and Hebei ranking third and fifth respectively (CSY, 2008). Henan's total electricity consumption in 2007 was 180.8 TWh and its rate of growth of electricity consumption follows a similar trend to the national rates (13-19 percent annual increases from 2003-2007).

As well as consuming significant amounts of electricity, Henan province is also a large producer of electricity, with more than a dozen power plants constructed close to a major provincial city (**Table 20**). With an abundance of coal to fire large thermal generators and the Yellow River to power large hydro-electric power stations, Henan province is a net exporter of electricity.

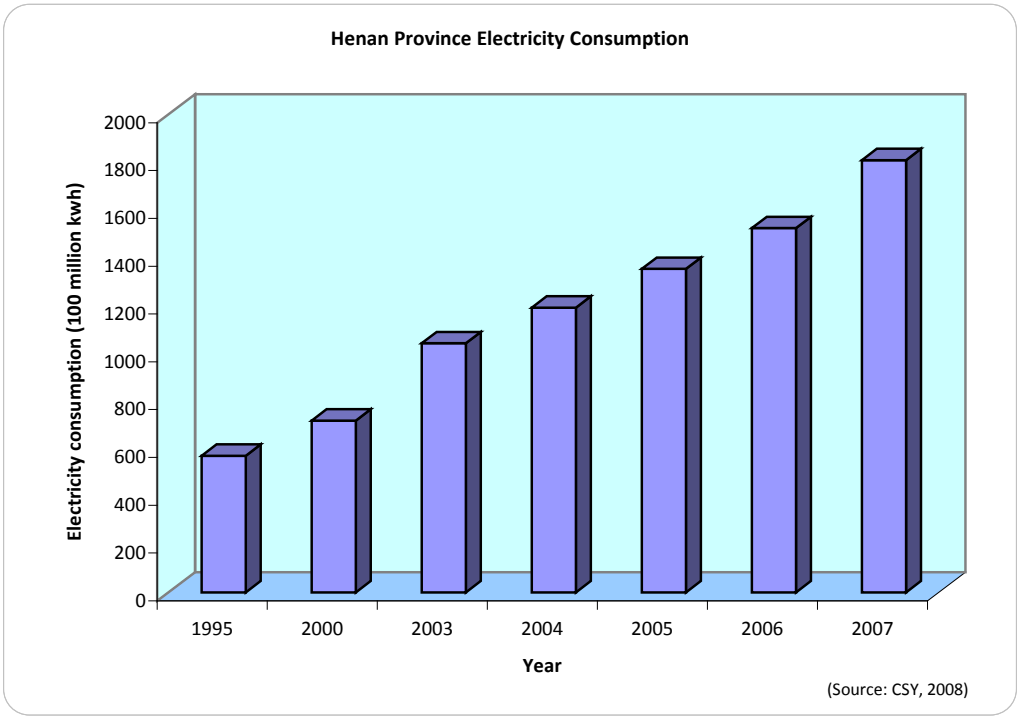



**FIGURE 24: HENAN PROVINCE ELECTRICITY CONSUMPTION (1995-2007)**

**TABLE 20: HENAN PROVINCE GENERATION PLANTS**

| Generation Plant | Owner | Fuel | Flood season capacity (MW) |
|---|---|---|---|
| Sanmenxia | China Datang Corp (CDC) | Hydro | 2,870 |
| Shouyangshan | CDC | Coal | 2,200 |
| Xiangtan | CDC | Coal | 1,800 |
| Lucyang | CDC | Coal | 960 |
| Anyang | CDC | Coal | 800 |
| Xinxiang | CDC | Coal | 1,250 |
| Xinxiang bacshan | CDC | Coal | 1,200 |
| Yaomeng | China Power Investment Corp (CPIC) | Coal | 2,400 |
| Jiaozuo | CPIC | Coal | 1,200 |
| Zhengzhou | CPIC | Coal | 1,000 |
| Qinbei | China Huaneng Group | Coal | 1,200 |
| Hebi | Henan Investment Group (HIG) | Coal | 2,200 |
| Yahekou | HIG | Coal | 1,900 |

| Generation Plant | Owner | Fuel | Flood season capacity (MW) |
|---|---|---|---|
| Baoquan | State Grid Corporation of China | Hydro (pumped storage) | 1,200 |
| Xiaolangdi | Yellow River Water & Hydropower Development Co. | Hydro | 1,800 |

Source: Pittman and Zhang (2008)

### 4.3.3 Hebi Area Electricity Market and Pricing

Hebi City, with a population of over 1 million and home to a wide range of industrial and manufacturing companies, purchased 2.5 billion kWh of electricity in 2008 from the national grid. Hebi also receives electricity from a 2,200 MW thermal power plant located in the city. Large electricity consumers include magnesium producers and cement manufacturers, such as the Tongli Cement Company which used 170 million kWh in 2007. The region's extensive dolomite resources have lead to Hebi becoming a center of magnesium production, an electricity intensive industry, along with the associated manufacture of magnesium by-products.

Hebi City has grown rapidly in the last decade and while year on year growth rates have declined, the region's extensive mineral resources continue to attract heavy and light industries and the workers needed to staff them. This in turn drives the expansion of the commercial sector. As such, electricity demand in the Hebi area is expected to increase in line with national projections, at rates between 5 to 10 percent per year.

Residential customers in Hebi pay between 0.52-0.56 RMB per kWh (7-8 cents/kWh) in the region while industrial users pay 0.33-0.49 RMB per kWh (5-7 cents/kWh). Hardest hit are commercial customers who pay 0.73-0.80 RMB per kWh (11-12 cents/kWh). Grid companies buy electricity from power companies at a cost of approximately 0.3-0.4 RMB per kWh (4-6 cents/kWh).

### 4.3.4 Central China Regional Grid

China is divided into six regional (transprovincial) grids that are largely independent, but engage in some electricity exchange through selected transmission links. Chongqing is one of six provincial level units that make up the Central China Electricity grid, which reports to the State Power Grid Corporation. Transmission links among the six provinces are owned by the Central China Electricity Grid Company, and the dispatch plans of the provincial level transmission-distribution companies are coordinated within the regional grid. The electricity distribution system in Henan province is part of the Central grid and the Hebi area sits in the middle of well-established, high-voltage grids. Urban distribution grids in the area are well developed.

Electricity consumption within the region covered by the Central China grid increased by 15 percent per year during the period from 2005-2007. Nonetheless, the Central China grid is a net power exporter to the rest of China, with generation exceeding supply within the grid by about 60,000 GWh in 2007. The

surplus comes from the rich hydropower resources in the region. Hydro accounted for about one third of the Central China grid's output in 2006, far and away the highest such percentage in the country. Particularly, the 18,200 MW Three Gorges megaproject in Hubei and the 3,300 MW Ertan project in Sichuan sold 40,100 and 1,670 GWh respectively to other regions in China in 2007 via dedicated transmission lines under long term contracts (SGCC, 2008). **Figure 25** below illustrates the electricity generated during 2005 – 2007.

**TABLE 21: CENTRAL CHINA POWER GRID SUPPLY AND CONSUMPTION**

| | **2005** | **2006** | **2007** |
|---|---|---|---|
| Electricity Supply (GWh) | 499,328 | 561,985 | 650,628 |
| *Chongqing* | 25,390 | 29,130 | 37,455 |
| *Hunan* | 64,441 | 75,490 | 86,015 |
| *Henan* | 141,468 | 160,050 | 191,826 |
| *Jiangxi* | 37,349 | 43,990 | 50,201 |
| *Hubei* | 128,980 | 130,667 | 158,839 |
| *Sichuan* | 101,700 | 122,658 | 126,292 |
| Total Electricity Consumption (GWh) | 450,000 | 511,566 | 590,675 |
| Generating Capacity (MW) | 108,800 | 129,200 | NA |

Sources: CESY (2008), p.43, 117, NBSC (2007), CEPY (2007), p.625

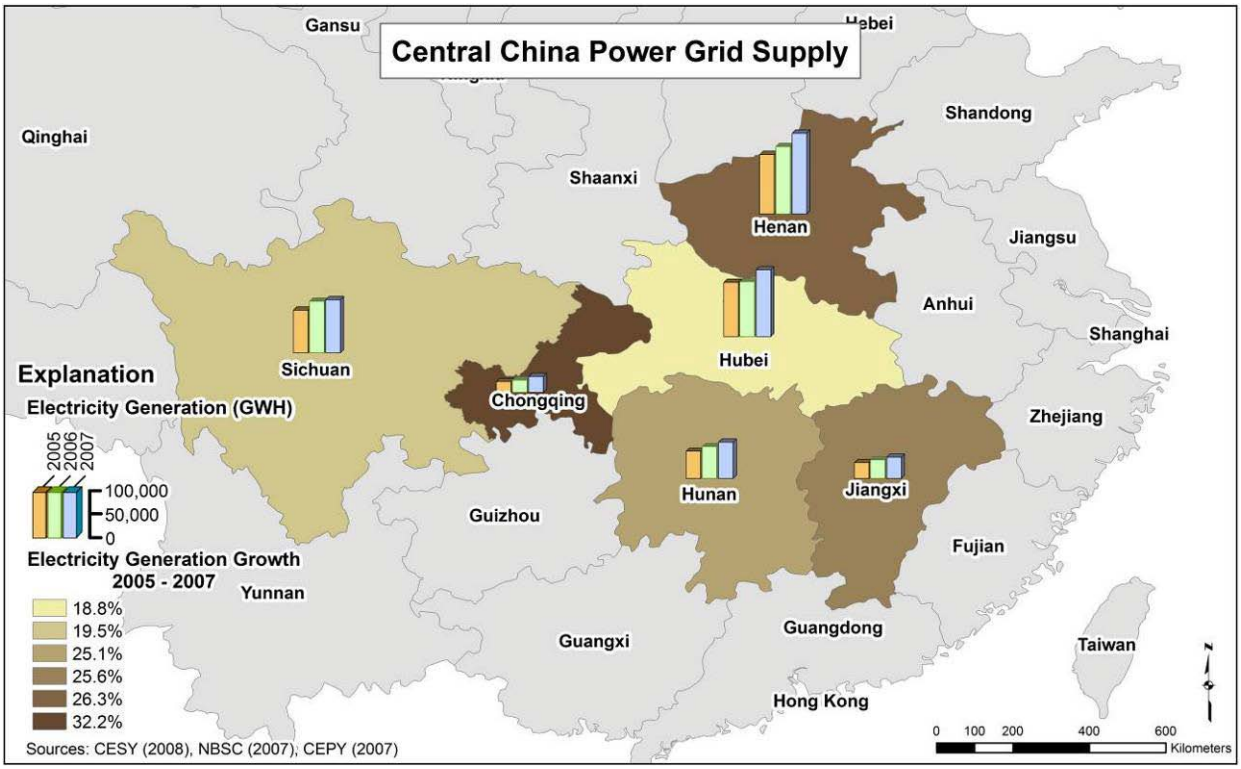



**FIGURE 25: CENTRAL CHINA POWER GRID SUPPLY**

### 4.3.5 Potential for Power Generated from CMM

It appears that, barring the rapid resumption of the industrial growth patterns of the 2003-2007 period, the market for thermal power in Chongqing will be soft for some time to come. This leaves little incentive for the Chongqing grid to buy power from proposed new plants burning coal mine methane at locations such as Songzao.

At the least, the grid would have to pay the going rate for coal-fired power plants. If regulations published by the NDRC in 2007 with the purpose of incentivizing coal mines to generate power using CMM were to be implemented, the grid would have to pay a 0.25 RMB per kWh supplement to the 2006 coal-fired wholesale price, which would raise the total to 0.577 RMB/kWh (NDRC, 2007.4). It is thus not surprising that the grid has no interest at the present time to pay for the considerable expenses of linking a prospective large-scale CMM power plant at Songzao to the major grid substations.

The Henan Power Grid Company (HPGC) would be the purchaser of any CMM power generated beyond the Hebi mines' own needs. As with Chongqing, the HPGC reports to the Central China Power Grid Company.

After a number of years during which production slightly exceeded consumption, Henan's electricity production fell short of demand by small margins in 2008 and 2009, and by a slightly higher margin (7 out of 235 terawatt hours) in 2010. If the supply gap were to continue to grow significantly, the HPGC would likely begin to show interest in developing alternative sources of supply such as CMM. As long as the shortage remains reasonably small, however, the HPGC is likely to find the price of excess

hydropower produced in other provinces of the Central China grid such as Sichuan and Hubei to be more attractive.

## 4.4 Guizhou/South China Grid

### 4.4.1 Electricity Supply Demand, Organizational Structure, Dispatch and Pricing

The Guizhou power grid is one of five interconnected provincial grids which are controlled by the state-owned China Southern Power Grid Company (CSPGC). While the Guizhou Power Grid Company (GPGC) under CSPGC manages the distribution of electricity within the province, the CSPGC controls the substantial electricity transfers between the provinces. Demand for power from generating plants in Guizhou should therefore be considered in a regional context.

Electricity consumption in the five CSPGC provinces grew at an average 9.5 percent per year from 2005-2009,, led by Guangdong Province, the regional economic powerhouse, which accounted for 57.5 percent of the CSPGC area's 627 Terawatt-Hours (TWh) electricity usage in 2009. As in the rest of China, growth exceeded 12 percent from 2005 to 2007, dropped sharply in 2008 and 2009, and rose again in the second half of 2009 and 2010, as China's economy rebounded strongly. Both the regional economy and regional power consumption can be reasonably projected to grow at 8-10 percent per year over the medium-term in line with anticipated national trends.

Within the CSPGC system, Guangdong is a significant net importer of electricity from the other provinces, while Guizhou is a significant net exporter. Overall, Guangdong relied on Guizhou for approximately 55 TWh, or 21 percent of its electricity in 2009. These exports to Guangdong accounted for about 40 percent of Guizhou's electricity output.

**TABLE 22: CHINA SOUTHERN POWER GRID ELECTRICITY BALANCES (TERAWATT HOURS)**

| | **2007** | | **2008** | | **2009** | |
|---|---|---|---|---|---|---|
| | Output | Usage | Output | Usage | Output | Usage |
| **Guangdong** | 273,197 | 339,405 | 266,288 | 350,482 | 266,640 | 360,940 |
| **Guangxi** | 68,281 | 68,114 | 84,800 | 76,082 | 92,299 | 83,637 |
| **Guizhou** | 116,632 | 71,409 | 119,208 | 67,918 | 138,002 | 77,440 |
| **Yunnan** | 90,450 | 74,552 | 103,970 | 82,948 | 117,382 | 89,119 |

Sources: CESY Tables 3-10 and 5-23, GDSB 2009, GSB 2010, Guangxi Economic Net 2010, GXSB 2010, YSB 2010

Guizhou's emergence as a major supplier to Guangdong is a direct result of central government directed investment to promote economic development in the poorer western provinces. Starting from 2000, state-owned power generation companies supported by government loans have built or are building 21,000 MW in 8 hydro and 12 coal-fired power plants in Guizhou, which sell the bulk of their output to Guangdong under long-term contracts (Guizhou Daily, 2008; China Energy Net, 2006).

To the extent possible, CSPGC appears to manage the distribution of the electricity from these plants for Guizhou's benefit. In 2008 and early in 2009, when electricity consumption in Guizhou declined particularly sharply, CSPGC increased the volume of power exported to Guangdong at the expense of

local Guangdong plants, whereas in the latter part of 2009 and 2010, as demand in Guizhou surged, CSPGC decreased the proportion exported to Guangdong.

Regardless of these short-term adjustments, Guangdong will continue to depend on significant volumes of electricity purchase from Guizhou and other CPSGC provinces for the foreseeable future, given the political commitments of the central government to Guizhou's development and the difficulties of installing sufficient in-province capacity to fully meet Guangdong's needs. Guizhou's electric power, furthermore, will remain strongly cost competitive in the Guangdong market in view of the availability in Guizhou of inexpensive local coal and water resources.

CSGPC currently pays slightly over 0.50 RMB per kilowatt hour for power from the new plants in Guangdong, burning coal shipped from North China or abroad, compared to 0.324 RMB per kWh for power generated from local coal in Guizhou. Hydropower is even less expensive (NDRC 2008.1a, 2008.2).

### 4.4.2 Guizhou Provincial Electric Power Market

Although Guizhou is one of China's smallest, poorest, and least urbanized provinces, its interconnections with the rest of the country have grown stronger in recent years, and its economic growth has closely tracked that of China as a whole. Electricity consumption within Guizhou has likewise followed the national/regional pattern, with strong double digit growth during 2005-2007 giving way to a temporary decline in the second half of 2008 and the first half of 2009 under the impact of the global economic slowdown, followed by a rebound carrying through into 2010 (**Table 23**).

**TABLE 23: GUIZHOU PROVINCE ELECTRICITY SUPPLY**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| **Installed Capacity (MW)** | NA | NA | 28,000 (est.) |
| - **Connected to Provincial Power Grid** | NA | NA | 26,190 |
| **Peak Load (MW)** | NA | NA | 11,870 |
| **Consumption (TWh)** | 71,409 | 67,918 | 77,440 |
| **Output (TWh)** | 116,632 | 119,208 | 138,002 |
| - **—Hydro Output (TWh)** | 34,062 | 38,086 | NA |
| - **—Thermal Output (TWh)** | 82,571 | 81,122 | NA |

Sources: CESY 2008 Tables 3-10, 3-11 and 3-12; GSYB 2009, GSB 2010, GPC 2009

Given this history, it is reasonable to assume that Guizhou's economy and its electricity consumption will grow within the projected eight to ten percent range for the country as a whole in the medium term. At the lower end of the range, electric load would increase from 12,000 MW in 2010 to 20,500 in 2016, and electricity consumption from approximately 77,440 TWh to 132,800 TWh.

The province's disproportionate economic dependence on energy-intensive extraction and manufacture of commodities such as coal, chemical fertilizers and their inputs/associated products, and aluminum, however, creates the potential for some volatility in electricity demand. Industry as a whole has consistently accounted for close to 80 percent of Guizhou's electricity consumption, the above-mentioned commodities for an estimated 55 percent, and a single massive aluminum smelter near Guiyang for about 15 percent (GSYB, GSB 2009).

Even a moderation in demand growth for these commodities, not to mention a sudden decline such as in the second half of 2008, would have a significant impact on electricity consumption in Guizhou. The more rapidly that Guizhou's economic base broadens and incomes and consumption rise, the less likely Guizhou is to deviate from national patterns of electricity consumption.

*Guizhou's Electricity Supply: Present and Future*

The Guizhou province electricity industry experienced an investment boom during the first decade of the 21st century, with generating capacity rising more than four-fold from 5,000 megawatts in 2000 to 28,000 by year-end 2009 (**Table 23** above). The bulk of this newly added capacity was either totally or partially dedicated to Guangdong Province under the "West-to-East" electricity program (Section 4.1.1 above).

Approximately 60 percent of the generating capacity burns coal from Guizhou's mines, with the remainder hydro, including about 2,000 MW of small-scale (under 50 MW) river hydro-plants. Because of fluctuations in river water levels, however, hydro only accounts for an estimated 31-32 percent of actual power generation. With the exception of the economic slowdown from the second-half of 2008 through the first-half of 2009, the major coal-fired plants in Guizhou have operated in a range of 6000-7000 hours a year, a high utilization rate by Chinese standards that reflects strong demand both inside and outside the province.

In 2009, Guizhou Governor Lin Shusen set a goal for the province to add 10,000 MW of additional electricity generating capacity "in the near term" in order to "turn Guizhou into one of China's premier energy producers". Nine large plants with an approximate 8,000 MW in aggregate capacity (1,850 MW hydro, the remainder coal-fired) were under construction in 2010, with expected completion by 2013. An additional four large coal plants with aggregate capacity of 5,720 MW were in the planning phase, with possible completion by 2015-2016 if all proceeds smoothly, including a 2 x 1,000 MW plant to be owned by China Power Investment Jinyuan Company, the parent of the Linhua Mine (Guizhou Power Plants).

Even if all 13,700 MW were to be completed according to schedule, however, only about 9,300 MW would represent additions to the capacity subject to dispatch by CSPGC. One of the new plants would sell its entire electricity output to Chongqing Municipality to the north. An additional five of the new plants would, if built, replace an aggregate 3,100 MW of existing coal-fired capacity composed of inefficient generating units of 200 MW or less, which are to be shut down under national policies mandating their retirement in favor of larger, more efficient units.[5] The replacement units include two

[5] The 2 x 600 MW Erlang plant has been promoted by Chongqing investors based on the premise that the electricity be sold in Chongqing; it will only be built if Chongqing commits to buy the power. There are plants summing 3,100 MW that have been or

of 600 MW capacity at Jinsha Power Plant fueled by coal from Linhua Mine in place of four 125 MW units which will be shut down.

Annual growth of eight percent would increase the Guizhou provincial electrical load by about 8,500 MW from the year-end 2009 level of 11,870 MW. In other words, Guizhou's own demand would likely account in whole or in part for the output of all but 800 MW of the 9,300 MW (net) generating capacity to be added by 2015-2016.

There is a high probability that output from the remaining capacity, or even additional capacity could be absorbed by Guangdong Province, whose load, at eight percent growth rates, would rise by 35,000 MW between 2009 and 2015. Approximately 32,000 MW of capacity (slightly less than 25 percent nuclear, the remainder coal) are either under construction or in advanced planning for completion by 2015 in Guangdong, but at least 3,000 MW of capacity composed of smaller, inefficient generating units are likely to be shut down when the new units come onstream.

### 4.4.3 Potential for Power Generated from CMM

Coal mine methane is among the more promising source of new, lower carbon energy sources in Guizhou Province. Most of the 138 million metric tons of coal mined in Guizhou during 2009 came from mines with seams that contain high volumes of methane that pose a considerable safety risk. Under the relatively conservative assumption that 15 cubic meters of methane were liberated per ton of coal mined, Guizhou Province emitted approximately 2 billion cubic meters of CMM in 2009 (pure methane), enough to supply over 1,300 MW of power capacity operating at 6000 hours per year at 40 percent energy conversion efficiency.

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will be shut down, including: 600 MW at Kaili that are being shut down in association with construction of new 1200 MW Fuquan plant; 658 MW Qingzhen Plant that is being shut down in association with construction of new 1200 MW Tangzhai Plant; 500 MW at Zunyi Plant that are shutting down in association with construction of new 1200 MW Tongzi Plant; 1040 MW that would be shut down at Xishui and Jinsha plants in conjunction with construction of new 1320 MW plant at Jinsha; 200 MW that would be shut down at Panxian Plant in conjunction with construction of 660 MW new plant. The policy to shut down small inefficient units and replace them with larger, efficient supercritical units of 600, 660 MW, or 1000 MW has been applied aggressively across China in accordance at central government insistence.

# 5. Gas Market

## 5.1 National Gas Market

Coal provides sixty-nine percent of the energy consumed annually in China, with only four percent provided by natural gas. Being considerably cheaper to produce than natural gas, coal will remain the dominant power source into the future, but the Chinese government is looking increasingly to mitigate the health and environmental problems associated with pollution from coal burning (especially in cities) by actively promoting the use of cleaner energy options, such as natural gas and coal mine methane. The government plans to increase the share of natural gas as part of total national energy consumption to ten percent by 2020.

### 5.1.1 Recent Trends in China's Natural Gas Market

After decades of stagnation, the natural gas market in China has experienced a surge of historic proportions in recent years. Production and consumption grew at average annual rates of 12 percent and 13 percent respectively from 1995-2008, and by 18.9 percent from 2003-2010. **Table 24** and **Figure 26** show China's natural gas market development by sector.

**TABLE 24: CHINA NATURAL GAS MARKET DEVELOPMENT, 1995-2008**

| | Production (million cubic meters) | LNG Imports (thousand tonnes) | Exports (million cubic meters) | Consumption (million cubic meters) |
|---|---|---|---|---|
| 1995 | 17,900 | NA | NA | 15,253 |
| 2000 | 27,200 | NA | 3,140 | 23,531 |
| 2001 | 30,300 | NA | 3,040 | NA |
| 2002 | 32,700 | NA | 3,200 | 27,544 |
| 2003 | 35,000 | NA | 1,873 | 34,829 |
| 2004 | 41,500 | NA | 2,440 | 40,798 |
| 2005 | 49,300 | NA | 2,970 | 46,474 |
| 2006 | 58,539 | 698 | 2,900 | 56,141 |
| 2007 | 69,310 | 2,931 | 2,600 | 70,520 |
| 2008 | 80,300 | 3,336 | 2,900 (est) | 81,290 |
| 2009 | 85,270 | 5,341 | 2,900 (est) | 89,520 |
| 2010 | 94,480 | 9,340 | 2,900 (est) | 110,000 |

Sources: CESY (2010), p. 119, 105, NBSC (2007); China Customs (2009.2); China Energy Bureau January 28, 2011.
(est) indicates estimated.

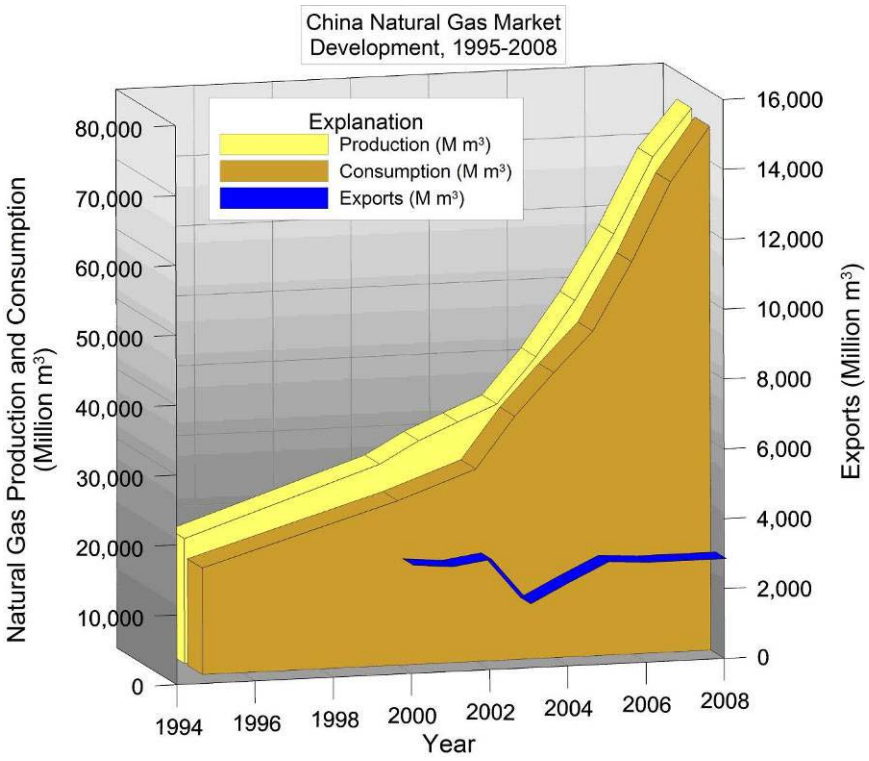


**FIGURE 26: CHINA NATURAL GAS MARKET DEVELOPMENT, 1995-2008**

Prior to the mid-1990s, natural gas consumption in China was restricted to Sichuan Province, the location of the only major on-land gasfields developed at that time, and to areas in the vicinity of major oilfields which burned small volumes of recovered associated gas. Almost 90 percent of the gas was used in industry, primarily as a raw material in ammonia/urea plants and as fuel for the oil and gas fields themselves.

A significant government policy in recent years has been to allow major privatization to take place in the urban gas distribution markets. Currently, there are hundreds of small formerly government-controlled city gas enterprises that are being consolidated into approximately one half-dozen much larger, modern, and mostly publicly listed companies. The private companies have better access to technology, capital, and management expertise. This privatization has helped to markedly accelerate China's consumption of natural gas in urban areas.

Today, these half-dozen major and mainly Chinese-owned gas companies compete to invest in China's rapidly growing urban markets, using capital funds raised on domestic, Hong Kong, and other stock markets. These companies aggressively bid on city gas assets at auction, acquire the equity interests of city gas enterprises through direct negotiation, or obtain indirect control of city gas operating concessions by jointly constructing and operating the systems with current municipal-owned city gas enterprises.

For example, China Gas Holdings Limited (China Gas), listed on the Hong Kong Main Board, is a major owner and operator of urban natural gas distribution systems in China. Notably, China Gas controls the city gas distribution company in Huainan, which is the nearest major city to Liuzhuang mine. China Gas invests in, operates, and manages the city gas pipeline infrastructure, the distribution of natural gas to

residential and industrial users, and the construction and operation of natural gas refilling stations. The company only just entered the natural gas distribution business in 2002, when China approved construction of the West-to-East Pipeline.

Today, China Gas has grown quickly and holds exclusive piped gas development rights in some 64 cities and regions in China, including Huainan. The company has a pipeline network more than 15,000 km long that serves 3.2 million household users and nearly 19,000 industrial and commercial users. In addition to city gas systems, China Gas also owns six high-pressure intermediary natural gas pipelines and 11 LPG terminals along China's southeast coast with capacity of 220,000 tons and LPG storage facility with 270,000 cubic meters capacity (Liu, 2008).

The Chinese central government's decision at the turn of the twenty-first century to develop long-distance pipelines to transmit gas from rich fields in remote areas of Northwest and North-Central China to the eastern heartland and to introduce imported LNG into the southern coastal areas has sparked an historic boom in China's natural gas consumption, which was unaffected by the economic turbulence of 2008-2009 and appears poised to continue for the foreseeable future. Natural gas usage increased at an average rate of almost 16 percent from 23.5 billion cubic meters in 2000 to approximately 88 billion in 2009 (CESY 2008 Table 5-12, NBSC 2010 Table 2, China Daily July 5 2010).

Even this impressive growth only brought the natural gas proportion of China's primary energy supply to 4-5 percent, compared to 23-24 percent in Europe and the USA. According to semi-official projections by NDRC's Energy Research Institute, demand for natural gas could rise by 20 billion cubic meters annually to a total of 300 billion by 2020 (People's Daily March 2010).

While the traditional chemical/fertilizer raw material end-use maintained its 33 percent share of total gas consumption from 1995-2005, it is clear that increased supply is opening up new markets for natural gas in China. Demand for natural gas is currently driven primarily by:

- Residential and commercial use: The substitution of clean, convenient natural gas for coal gas, LPG, or coal briquettes as a household fuel has proven extremely popular as residential natural gas distribution networks have been constructed for the first time in the major eastern population centers. Nonetheless, only about one in six residents of the country's constantly expanding cities and townships enjoyed access to natural gas as of 2007 (CESY 2008, Table 3-13). These two categories combined accounted for over 21.7 percent of consumption in 2007, compared to only 11 percent in 1995, and the percentage continues to increase. See **Table 25**, **Figure 27**, and **Figure 28** below.
- Industrial use: Where available, natural gas fuel is being systematically substituted for liquid hydrocarbons or coal gas in petrochemical factories, glass plants, steel mills, etc.

Secondary end-use sectors include:

- Electric power generation: At central government direction, dozens of state-of-the-art combined cycle power plants were constructed between 2000 and 2010 to provide guaranteed off takers for the new long-distance pipelines and LNG terminals. The pace of construction, however, will likely slow down in coming years now that the scale of demand from the residential sector has become apparent. Gas-fired combined cycle power plants with at least 20,000 MW of capacity are coming on-stream in the 2005-2010 period, which if run at 3500 – 4000 hours per year as planned, will consume an average 15 billion cubic meters of gas per year. Gas-fired combined

cycle power plants will account for more than half of the consumption of the two operating LNG terminals in Guangdong and Fujian provinces.

- Automotive: The low price of natural gas relative to gasoline in China has stimulated the development of a compressed natural gas (CNG) distribution infrastructure in a number of Chinese cities. Under central government prodding, however, local governments are taking administrative measures to ensure that automotive consumption does not crowd out usages such as household fuel that are considered higher priority.
- Cement manufacture: consumption as fuel in "non-metallic minerals" manufacture, which in China means mainly cement, rose more than 10-fold to about 2 billion cubic meters (4.5 percent of total national consumption) in the period from 1995 to 2007. See **Table 25**, **Figure 27**, and **Figure 28** below.

**Table 25**, **Figure 27**, and **Figure 28** below show China's natural gas consumption by sector for years 1995 and 2007.

**TABLE 25: CHINA: NATURAL GAS CONSUMPTION BY SECTOR (MILLION CUBIC METERS)**

| | **1995** | | **2000** | | **2005** | | **2007** | |
|---|---|---|---|---|---|---|---|---|
| | Volume | % | Volume | % | Volume | % | Volume | % |
| **TOTAL** | **17,741** | **100.0%** | **24,503** | **100.0%** | **46,763** | **100.0%** | **69,523** | **100%** |
| | | | | | | | | |
| **INDUSTRY** | **15,439** | **87.0%** | **20,200** | **82.4%** | **35,379** | **75.7%** | **50,967** | **73.3%** |
| | | | | | | | | |
| ***Mining*** | ***5,187*** | ***29.2%*** | ***7,302*** | ***29.8%*** | ***8,799*** | ***18.8%*** | ***9,632*** | ***13.9%*** |
| Petroleum Extraction | 5,058 | 28.5% | 7,288 | 29.7% | 8,346 | 17.8% | 9,108 | 13.1% |
| | | | | | | | | |
| ***Manufacturing*** | ***10,080*** | ***56.8%*** | ***12,081*** | ***49.3%*** | ***23,921*** | ***51.2%*** | ***33,321*** | ***47.9%*** |
| Petroleum Processing and Coking | 1,514 | 8.5% | 1,342 | 5.5% | 1,952 | 4.2% | 2,652 | 3.8% |
| Chemical Manufacturing | 6,336 | 35.7% | 9,032 | 36.9% | 15,443 | 33.0% | 22,343 | 32.1% |
| Non-metallic mineral manufacturing | 227 | 1.3% | 250 | 1.0% | 2,604 | 5.6% | 3,125 | 4.5% |
| Iron and Steel Making | 369 | 2.1% | 171 | 0.7% | 1,068 | 2.3% | 1,422 | 2.0% |
| Nonferrous Metals | 50 | 0.3% | 50 | 0.2% | 423 | 0.9% | 579 | 0.8% |
| Transport Equipment | 66 | 0.4% | 171 | 0.7% | 537 | 1.1% | 715 | 1.0% |
| Electronic Equipment | 101 | 0.6% | 341 | 1.4% | 522 | 1.1% | 666 | 1.0% |
| | | | | | | | | |

| | 1995 | | 2000 | | 2005 | | 2007 | |
|---|---|---|---|---|---|---|---|---|
| | Volume | % | Volume | % | Volume | % | Volume | % |
| ***Utilities*** | ***172*** | ***1.0%*** | ***817*** | ***3.3%*** | ***2,660*** | ***5.7%*** | ***8,013*** | ***11.5%*** |
| Electricity and Heat | 114 | 0.6% | 644 | 2.6% | 1,881 | 4.0% | 7,078 | 10.2% |
| Gas distribution | 58 | 0.3% | 171 | 0.7% | 772 | 1.7% | 927 | 1.3% |
| | | | | | | | | |
| **TRANSPORT, STORAGE, POST** | **157** | **0.9%** | **581** | **2.4%** | **1,301** | **2.8%** | **1,689** | **2.4%** |
| | | | | | | | | |
| **COMMERCIAL** | **55** | **0.3%** | **344** | **1.4%** | **1,079** | **2.3%** | **1,711** | **2.5%** |
| | | | | | | | | |
| **RESIDENTIAL** | **1,941** | **10.9%** | **3,232** | **13.2%** | **7,943** | **17.0%** | **13,339** | **19.2%** |
| | | | | | | | | |
| **OTHER** | **147** | **0.8%** | **146** | **0.6%** | **1,061** | **2.3%** | **1,609** | **2.3%** |

Source: CESY (2008), pp. 104 – 105

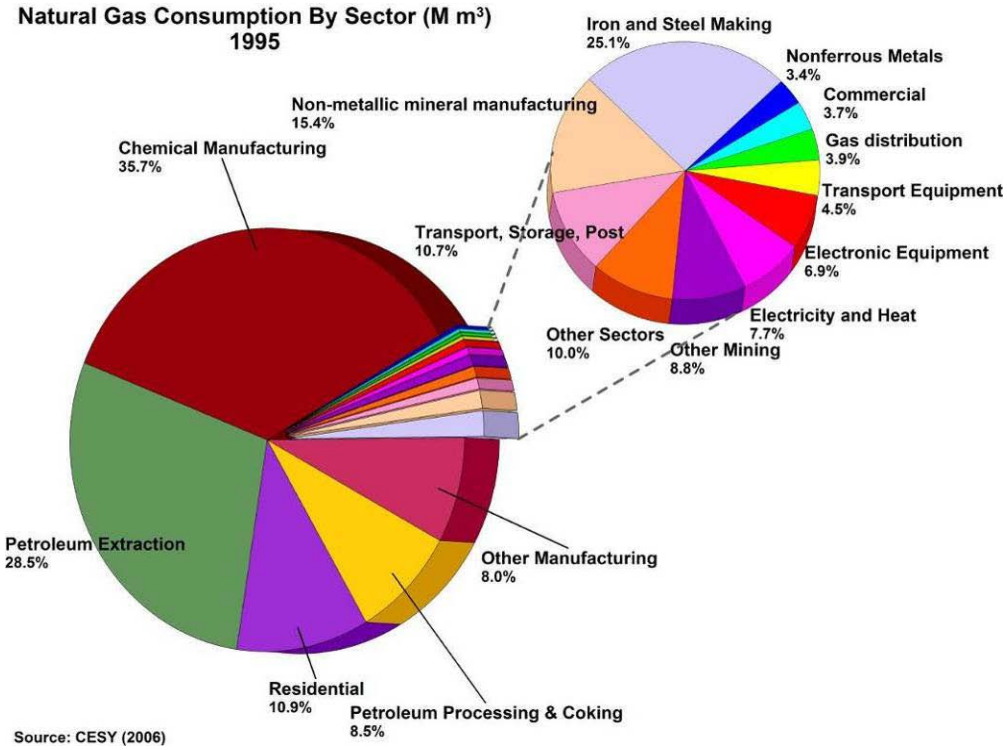


**FIGURE 27: CHINA'S NATURAL GAS CONSUMPTION BY SECTOR, 1995**

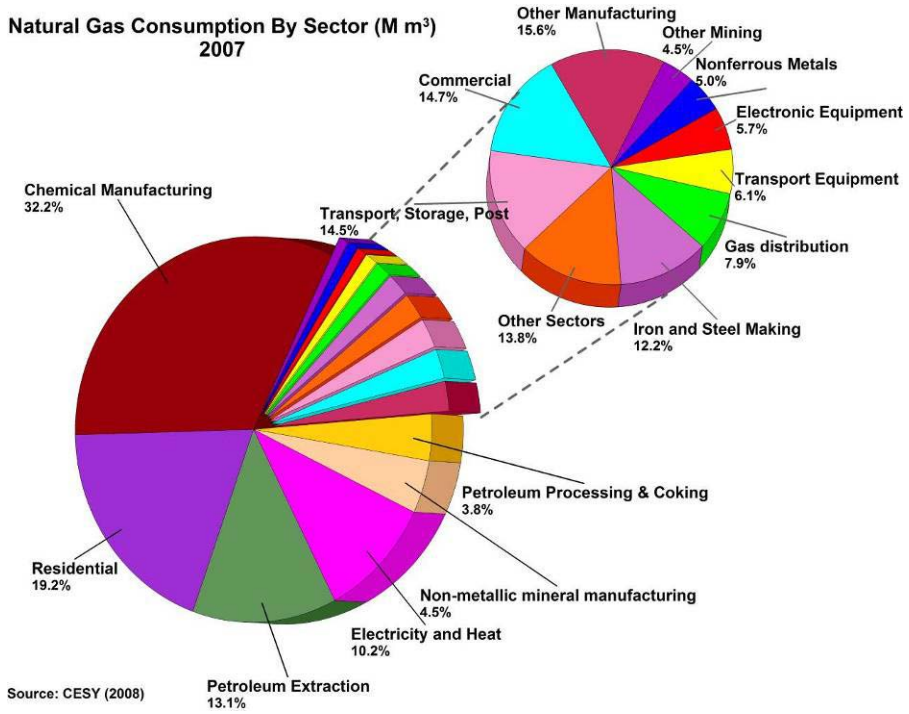


**FIGURE 28: CHINA'S NATURAL GAS CONSUMPTION BY SECTOR, 2007**

*Impact of Economic Slowdown on Natural Gas Demand*

Insufficient data is available as of early 2009 to assess the impact on natural gas demand of the slowdown in the rate of economic growth caused by the sudden contraction in exports associated with the world economic crisis. The economic crisis was accompanied by the drop in production of heavy industrial materials such as metals, caused by a policy-induced slowdown in real estate investment. These events have had an obvious adverse effect on coal and electricity demand starting from the fourth quarter of 2008, but there are a number of reasons to believe that the impact will not be nearly as large on natural gas, including:

- The concentration of increased natural gas consumption in the residential sector. Although there are significant pockets of urban unemployment and return of potential natural gas consuming workers to the countryside associated with the shutdown of export processing factories, certain data suggest that urban consumption generally has not been impacted by the slowdown as of late 2008. According to the China National Statistics Bureau, urban consumption in November 2008 was 20.3 percent higher than in November 2007, broadly consistent with trends earlier in the year (NBSC, 2008).
- The concentration of industrial consumption in the chemical fertilizer industry, which serves domestic agriculture. There has been no suggestion that Chinese agriculture will be seriously affected by either the global crisis or a slowdown in Chinese real estate/factory investment. And even a temporary slowdown in the output of steel, etc. need not necessarily affect fuel switching from coal gas or heavy oil to natural gas in these industries.

- The 4 trillion RMB domestic Chinese stimulus package, with its emphasis on infrastructure construction will cushion the blow of the global economy and the domestic real estate slowdown. The World Bank projected that the Chinese economy as a whole would grow 7.5 percent in 2008 – significantly lower than the double digit rates prevailing since the turn of the century, but still robust -- with the stimulus package accounting for as much as half of this growth (WB, 2008).

Most importantly, companies in the natural gas sales business indicate that there had not as of year-end 2008 been any signs of slowdown in their markets. This study therefore assumes:

(1) The growth rate of natural gas consumption by an average of 10 billion cubic meters per year for the foreseeable will not be affected by the world economic downturn and the lower rates of growth in China caused both by that downturn and domestic factors in China.
(2) The duration of any such slowdown in gas consumption growth as may occur will be of short enough impact to eliminate any adverse impact on the proposed Songzao project.

These assumptions will have to be tested against reality as time progresses. In particular, potential investors should monitor whether the rate of urbanization slows down, urban unemployment increases, or disposable income decreases sufficiently to adversely affect previous patterns of growth in urban consumption of basic utilities such as natural gas. They should also pay attention to whether the drop in heavy industrial growth is of a magnitude and duration as to significantly reduce the rate of growth of industrial natural gas consumption.

#### *5.1.1.1 Coalbed and CMM*

CBM and CMM are gradually emerging as a complementary natural gas resource. Approximately one billion cubic meters of over 90 percent methane concentration CBM were recovered nationally in 2009 (**Table 26**). This CBM was recovered from surface wells drilled by either by coal mines or other concession holders, almost entirely from the Qinshui Basin near Jincheng in Southeast Shanxi Province Only about half of this quantity was utilized, but the percentage will increase considerably in the near future upon completion by the CNPC of a major processing center hooked up to the Xinjiang-Shanghai trunk pipeline. Three small-scale LNG plants will process over 600 million cubic meters of CBM from Jincheng Coal Mining Group and other operators when fully operational (NDRC 2009, World Bank 2009, China LNGNet, 2009).

The vast majority of China's liberated CMM is emitted to the atmosphere as low-concentration ventilation air methane (VAM). But recovery of between 10 to 50 percent concentration CMM by drainage in association with mining doubled to 6.45 billion cubic meters (100 percent methane basis, same with all numbers below) between 2006 and 2009, with usage rising to almost two billion cubic meters.

**TABLE 26: CBM/CMM RECOVERY AND UTILIZATION IN CHINA (BILLION CUBIC METERS)**

| | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|
| **CMM from Coal Mines (excluding VAM)** | | | | | |
| -- Recovery | 2,300 | 3,200 | 4,700 | 5,300 | 6,450 |
| -- Utilization | 600 | 1,100 | 1,400 | 1,600 | 1,930 |
| **CBM from Surface Wells** | | | | | |
| -- Recovery | | | | 490 | 1,010 |
| -- Utilization | | | | 370 | 580 |
| **Total CMM and CBM** | | | | | |
| -- Recovery | | | | 5,790 | 7,460 |
| -- Utilization | | | | 1,970 | 2,420 |

*Source: NDRC 2010.2*

Most CMM is consumed in the immediate coal mining areas either in small distributed power stations or as household, commercial or industrial fuel, with a small number of mines with high recovery volumes having developed central station power plants or industrial facilities to burn CMM.

Cryogenic technologies to purify and liquefy medium-methane content CMM that are already proven outside of China, offer the potential to integrate CMM into the national natural gas market. Chinese domestic companies are also developing this technology. A 100 million cubic meter plant is being constructed at SCEC in Chongqing Municipality.

### *5.1.1.2 Domestic Production of Natural Gas*

China enjoys only modest domestic endowments of conventional natural gas, and the great majority of known deposits are located distant from population and industrial centers. The consumption growth over the past 10 years has depended primarily on exploitation of previously virgin fields in the remote northwestern Tarimince and Ordos basins. These fields, together with a smaller field in the Qaidam Basin of Qinghai Province and the existing fields in Sichuan and Chongqing, accounted for over 90 percent of China's reported 85.1 billion cubic meter conventional natural gas output in 2009.

The CNPC has over the past 10 years completed interconnected pipelines from Xinjiang to Shanghai (3,900 km long, 17 billion cubic meters capacity throughput) and from northern Shaanxi Province to Beijing (900 km length, 15.5 billion cubic meters capacity throughput) to bring gas from Tarim and Ordos basins respectively, to major load centers in the east. Additional long-distance pipelines constructed both by CNPC and by Sinopec, the number two upstream producer, transmit gas from Sichuan/Chongqing along the Yangtze River valley to Shanghai and provinces in between.

Through mid-2010, however, entire provinces in the south, such as the economic powerhouse of Guangdong, as well as Fujian, Guangxi, Yunnan and Guizhou, have remained unconnected to the rudimentary national pipeline grid. Even in provinces with access to long-distance pipelines, the intra-provincial distribution pipelines constructed by local governments and private interests extend neither to many medium and small-sized cities nor to all neighborhoods in the larger cities. This incomplete coverage of the pipeline network has created market openings for over a dozen small LNG plants

constructed over the last five years, which ship their product by tanker truck to cities in the east and the south of China, which have no other access to natural gas. Gas sources for these plants include small onshore or offshore gasfields, coalbed methane (CBM), and in some cases pipeline gas resold by local government companies attracted by the high prices that can be commanded in areas unconnected to the pipeline grid.

### *5.1.1.3 Civil and Commercial Use of Natural Gas*

Now that government policy actively encourages residential use of natural gas and significant numbers of urban residents are finally experiencing the environmental benefits and the convenience of natural gas relative to competing household fuels, such as liquefied petroleum gas, coal gas, and coal, demand for residential natural gas use is rising rapidly. Local governments in all areas of the country are scrambling to obtain access to natural gas, and private as well as publicly owned natural gas distribution networks are sprouting up in cities all over the country.

Of the estimated 577 million people living in Chinese cities, suburbs, and towns, only 102 million had access to natural gas at year-end 2005. Entire provinces, such as Guizhou, Yunnan, Guangxi, Jiangxi, and Fujian offered virtually no gas to their urban residents, and even highly developed provinces such as Guangdong and Jiangsu only offered gas to 18 and 6.6 percent of their respective city and town dwellers.

**Figure 29** shows China's population distribution and **Figure 30** shows China's urban population with access to natural gas by province.

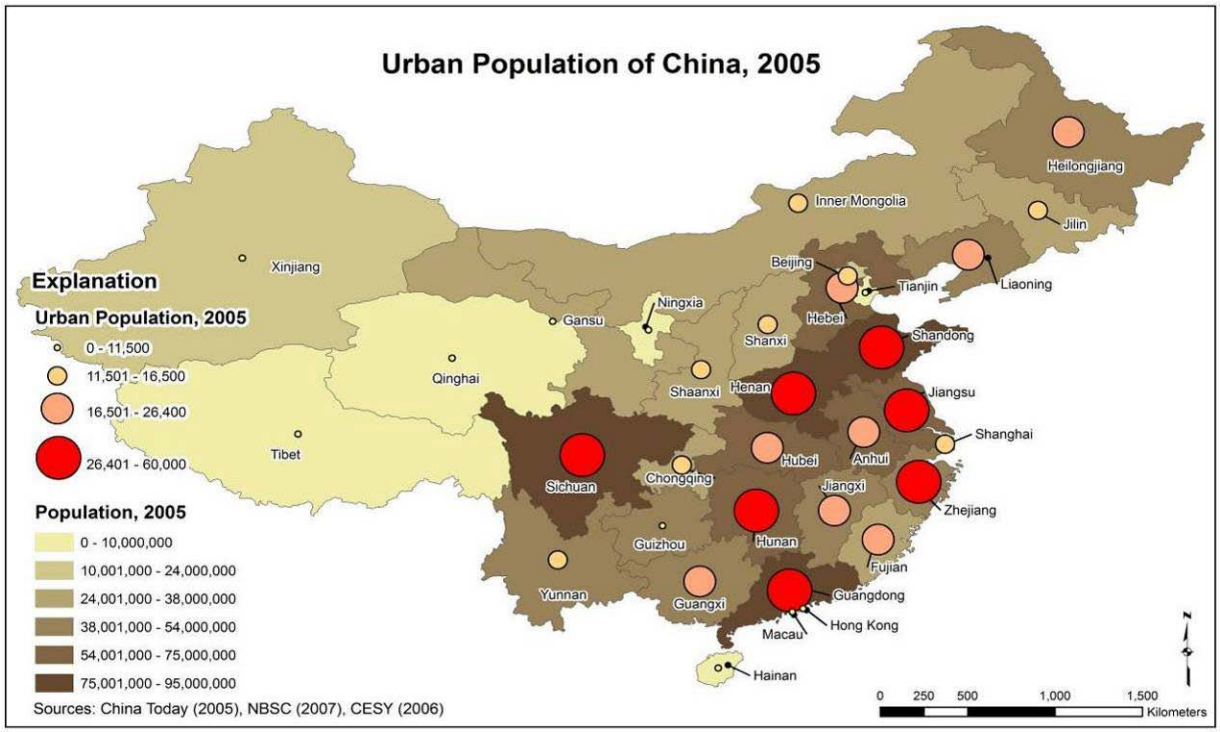


**FIGURE 29: URBAN POPULATION OF CHINA, 2005**

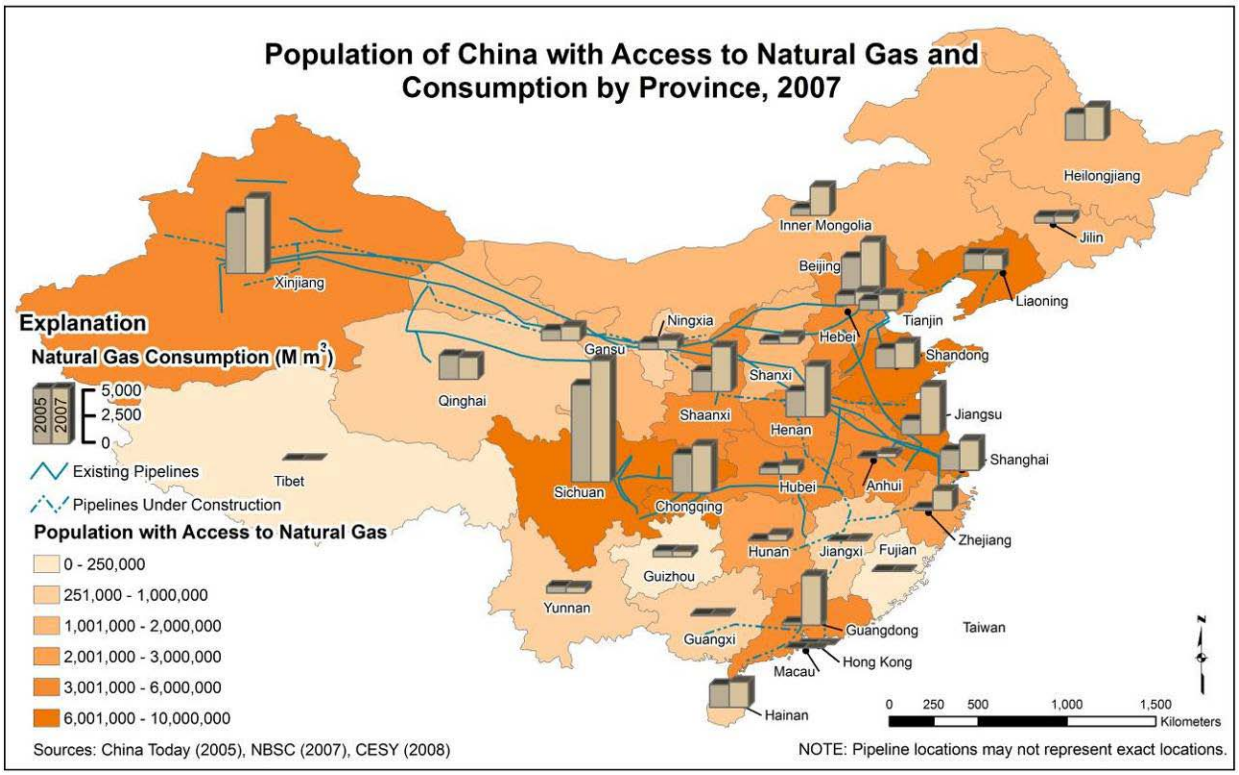


**FIGURE 30: POPULATION OF CHINA WITH ACCESS TO NATURAL GAS AND CONSUMPTION BY PROVINCE, 2007**

### *5.1.1.4 Industrial Fuel*

The central government's 2007 white paper on natural gas use called for substitution of natural gas for fuel oil and coal gas in industry where possible. In 2005, Chinese industry consumed a reported 19.8 million tonnes of fuel oil (CESY 2008, p. 103); if the thermal value of number 6 fuel oil is assumed to be 42,390 kj/kg, and that of natural gas 38,000 kj/cubic meter, this implies a potential market size of order of magnitude 20 billion cubic meters of gas from fuel oil substitution. Anecdotal evidence suggests that this shift is gradually taking place, particularly at oil refineries.

Provincial and sub-provincial governments are also applying pressure on local industry to convert from coal or coal gas to natural gas fuel in order to improve air quality. Just one enterprise – the Yaohua Glass Company in Qinhuangdao, Hebei Province - will consume 400 million cubic meters of natural gas by 2011 after making the switch.

Planners of the 30 billion cubic meters per year Central Asia – China gas pipeline assume that close to 30 percent of its throughput will be consumed as an industrial fuel as similar conversions take place (Xinhua, 2008). As with residential use, gas supply is the only limit to increased use of natural gas as an industrial fuel.

### *5.1.1.5 Power Sector*

Combined cycle electric power plants have been an important source of demand for natural gas over the last five years, accounting for at least half of the allocation of the first West to East pipeline, and for about two thirds of the allocation from the first two LNG terminals in operation in Guangdong and Fujian. They appear unlikely, however to play as important a role in new demand over the coming three to five years.

Over 20,000 MW of large combined cycle power plants were built in the 2005-2008 period, driven both by acute power shortages, and by central and local government concern that there be firm off takers for the gas coming through the new pipelines and LNG import terminals. All indications are that the unexpectedly strong demand in the residential/commercial sector has increased the willingness of municipal distribution company off takers to commit to pipeline companies for future projects, and lessened the pressure to construct new combined cycle power plants simply to ensure the success of the pipelines. CNPC projects that only about 15 percent of the throughput from the new Central Asia-China pipeline will be sold to power plants (Xinhua, 2008).

The high price of gas relative to coal (at 400 RMB per tonne for 5000 kcal/kg coal and 1.5 RMB per cubic meter of gas, coal is approximately 40 percent cheaper than gas per kWh) has led the grid to use them as peak regulation plants producing at 3500-4000 hours per year, rather than base-loaded plants, despite their high thermal efficiency. The rapid run-up in coal prices of first half 2008 may have closed this gap in some places, but the decline of second half 2008 has almost certainly restored it.

The overall softening of the Chinese power market in late 2008 may also act as a further inhibitor on the construction of new combined cycle power plants in the near term. A return to rapid growth for combined cycle power plants will likely require a change in economics of gas relative to coal and/or a stronger environmental commitment by the government to substitute for coal-fired power.

#### *5.1.1.6 Automotive Sector*

NDRC listed automotive fuel as one of the encouraged uses of natural gas in its 2007 white paper. Favorable pricing relative to gasoline appears to be the main driver behind CNG use, and growth in this sector will depend on the price relationship between the fuels in the future. The central government has indicated a desire that the price of CNG be at least 75 percent of that of gasoline on a heat value basis in order to avoid excessive diversion of natural gas to the automotive sector (NDRC 2007.3).

#### *5.1.1.7 LNG Market*

The central government has recognized since the turn of the century that imports would be a necessary component of the natural gas supply when it committed to building massive LNG import terminals along the southern coast. The achievement of the very ambitious gas supply targets over the next 10 years are likely to depend at least as much on imports as on increased domestic production.

Imports of LNG into the first three coastal terminals in Guangdong, Fujian and Shanghai reached eight billion cubic meters equivalent in 2009, close to ten percent of total national consumption (China Daily July 5, 2010). An additional 15.9 million metric tons (21.2 billion cubic meters equivalent) of large import LNG receiving capacity have been permitted by NDRC and are under construction by the three

state-owned oil companies in other coastal locations. The companies have moved steadily to lock up long-term supply contracts with major producers in Australia, Indonesia, Malaysia, and Qatar.

In addition to importing LNG, the Chinese government is introducing imported pipeline natural gas through the following transactions:

- Long-term contract by CNPC to purchase 30 billion cubic meters of gas per year from Turkmenistan, coupled with construction of nearly 8,000 km of pipelines to transmit the gas to the eastern and southern coastal provinces, including Guangdong. This pipeline is coming onstream in stages during the 2010-2011 period.
- Agreements with the government of Burma and a Daewoo offshore gas production consortium for CNPC to purchase 12 billion cubic meters per year from two Burmese offshore blocks and to construct approximately 2,800 km of pipelines through Burma to the southwestern provinces of Yunnan, Guizhou, and Guangxi. Work on the pipeline is reported to have begun in 2010, and is projected to be completed in 2013.

A government-owned company China National Offshore Oil Corporation (CNOOC) has completed two large LNG import terminals which have inaugurated the use of natural gas in urban areas of the southern coastal provinces of Guangdong and Fujian.

**TABLE 27: CHINA OPERATING LARGE-SCALE LNG RECEIVING STATION PROJECTS**

| Location | Capacity | On-stream | Gas Source | Gas Use |
|---|---|---|---|---|
| Shanghai (CNOOC) | 3 million tonnes (4 billion cubic meters equivalent) | 2009 | Malaysia | NA |
| Fujian | 2.6 million tonnes (3.5 billion cubic meters equivalent) | 2008 | Indonesia | Three large power plants (65%); municipal distribution in 5 cities (35%) |
| Shenzhen | 3.7 million tonnes (5 billion cubic meters equivalent) | 2006 | Australia | Five power plants (70%); municipal distribution in Guangzhou, Shenzhen, Dongguan, Foshan (30%) |

Sources: ChinaPower July 4, 2006; People's Daily Online, June 29, 2006; Xinhuanet, September 12, 2004; WhatsonXiamen, May 9, 2008

*LNG Import Terminals*

In addition to the two major LNG import terminals already operating in Shenzhen (Guangdong) and in Fujian Province, at least nine others are planned by the state-owned oil companies along the coast. Four of these – in Shanghai, Zhuhai (Guangdong), Dalian, and Jiangsu—with aggregate capacity of 12.5 million tonnes, or approximately 16.5 billion cubic meters per year regasified, are reported under construction.

Of equal importance, **Table 28** lists the long term LNG supply contracts that have been signed for these projects. **Table 29** lists proposed LNG import terminal projects.

**TABLE 28: LNG SUPPLY CONTRACTS**

| Supplier | Buyer | Date Signed | Volume (tpy) |
|---|---|---|---|
| Petronas (Malaysia) | CNOOC/Shanghai | 2006 | 1.1million (2009-2011)<br>3 million (2012-2034) |
| Qatargas | CNPC | November 2008 | 3 million (2011-2036) |
| Shell | CNPC | November 2008 | 2 million (2011-2031) |
| Qatargas | CNOOC | June 2008 | 2 million (2009-2034) |
| Total (France) | CNOOC | June 2008 | 1 million (from 2010) |

Sources: Xinhua January 23, 2007; Shell October 4, 2008; Xinhua November 25, 2008; China Daily June 25, 2008

**TABLE 29: PROPOSED LNG IMPORT TERMINAL PROJECTS, 2008-2010**

| Location and Sponsor | Capacity | Status | Gas Source |
|---|---|---|---|
| Dalian, Liaoning (CNPC PetroChina) | 3 million tonnes (4 billion cubic meters equivalent) | Construction, due on-stream 2011-2012, includes pipelines to Shenyang and Fushun | Qatar, Australia |
| Ningbo, Zhejiang (CNOOC) | 3 million tonnes (4 billion cubic meters equivalent) | Construction On-stream 2012 | Not settled |
| Zhuhai, Guangdong (CNOOC) | 3.5 million tonnes (4.8 billion cubic meters equivalent) | Civil construction On-stream 2013 | Own resources/Qatar |
| Rudong, Jiangsu (CNPC) | 3.5 million tonnes (4.8 billion cubic meters equivalent) | Construction On-stream 2011 | Qatar/Shell |
| Yangpu, Hainan (CNOOC) | 3 million tonnes (4 billion cubic meters equivalent) | Construction On-stream 2014 | Qatar, other |
| Tangshan, Hebei (CNPC PetroChina) | 3 million tonnes (4 billion cubic meters equivalent) | Construction On-stream 2013 | Qatar, Australia |
| Qingdao, Shandong | 3 million tonnes | Civil Construction | Exxon Papua New |

| Location and Sponsor | Capacity | Status | Gas Source |
|---|---|---|---|
| (Sinopec) | (4 billion cubic meters equivalent) | On-stream 2013 | Guinea, Other |
| Tianjin (Sinopec) | 3 million tonnes (4 billion cubic meters equivalent) | Planning | Not settled |

Sources: Xinhua, January 23, 2007; PetroChina, June 2, 2008; PetroChina, April 23, 2008; Bloomberg, November 28, 2008; China Daily, June 25, 2008; ChinaMining.org, January 23, 2008; Guangzhou Daily, October 22, 2010; Hainan Municipal Website, August 2, 2011; China Daily, August 10, 2009; Peninsula Daily News, September 19, 2011; China Daily, December 4, 2009; Chinagate, March 23, 2009; China Development Gateway Network, March 25, 2009; China Central Television, March 24, 2010.

### 5.1.2 Gas Pipelines

The key to the expansion over the past decade has been the decision of the Chinese central government, acting through PetroChina,, Sinopec, and the state-owned banking system, to aggressively develop gasfields in remote areas of western China and, for the first time in the country's history, to build long-distance pipelines to connect these sources (as well as the existing Sichuan gasfields) to major population and industrial centers in the eastern part of the country. As a direct result, some of China's largest cities, including Beijing, Shanghai, Nanjing, Wuhan, Changsha, Xian, and Lanzhou as well as numerous smaller and medium sized cities in the surrounding provinces are burning natural gas for the first time.

**TABLE 30: CHINA MAJOR LONG-DISTANCE GAS PIPELINES, 1995-2007**

| Pipeline | Length (km) | Design Capacity (million cubic meters) | Gas Source | Date in Operation |
|---|---|---|---|---|
| Jingbian County (Shaanxi) – Beijing | 853 | 3,500 | Changqing (Shaanxi – Inner Mongolia) | 1997 |
| Jingbian County (Shaanxi) – Beijing Number 2 | 935 | 12,000 | Changqing (Shaanxi – Inner Mongolia) | 2006 |
| Jingbian County (Shaanxi) – Xian | 488 | 1,000 | Changqing (Shaanxi – Inner Mongolia) | 1997 |
| Jingbian County (Shaanxi) – Xian | 476 | 1,500 | Changqing (Shaanxi – Inner Mongolia) | 2005 |
| Sebei – Golmud (Qinghai) | 190 | 700 | Sebei Field, Qinghai | 1996 |
| Sebei – Xining (Qinghai) -Lanzhou (Gansu) | 953 | 2,000 | Sebei Field, Qinghai | 2001 |
| West to East | 3,900 | 12,000 (original) | Tarim Basin, | 2005 |

| | | | | |
|---|---|---|---|---|
| pipeline: Xinjiang - Shanghai | | 17,000(expanded) | Xinjiang, and Changqing | 2009 |
| Yizheng (Jiangsu) – Anping (Hebei) connector pipeline | 886 (1498 including branches) | 9,000 | West to East and Second Jingbian-Beijing pipelines | 2006 |
| Chongqing – Wuhan | 695 | 3,000 | Sichuan Gasfields | 2005 |
| Huaiyang (Henan) – Wuhan connector pipeline | 475 | 1,500 | Chongqing-Wuhan and West to East pipelines | 2007 |

Sources: Xinhuanet December 12, 2001; China Central Government Website December 16, 2006; Yangtze Evening News December 31, 2005; China Oil and Gas Pipeline Website March 29, 2004; China Oil Network Website September 22, 2005; General Electric Company November 24, 2008; China Daily August 5, 2005

*Second West to East Gas Pipeline*

With a designed throughput of 30 billion cubic meters per year and estimated cost of 140 billion RMB (about $20 billion USD), this project involves the following:

- Construction of 1,818 km of pipeline through Uzbekistan and Kazakhstan to the Chinese border at Xinjiang.
- Construction of 4,945 km of trunk pipeline through China to Guangzhou.
  Construction of 8 branch pipelines totaling 3,849 km to load centers throughout eastern, central, and southern China (Xinhua, 2008).

A reported 13 billion cubic meters will come from fields developed by PetroChina in Turkmenistan, under production sharing agreements with the remainder purchased from Turkmeni oil companies.

Construction of the China portion of the pipeline has begun in 2008, with first gas flow projected for 2010, and achievement of full capacity in 2012. As far as can be determined, the project is being financed by a combination of equity from PetroChina and other Chinese investors, corporate bonds issued by PetroChina, and loans from Chinese government banks. **Figure 31** below shows consumption of Sinopec gas by sector.

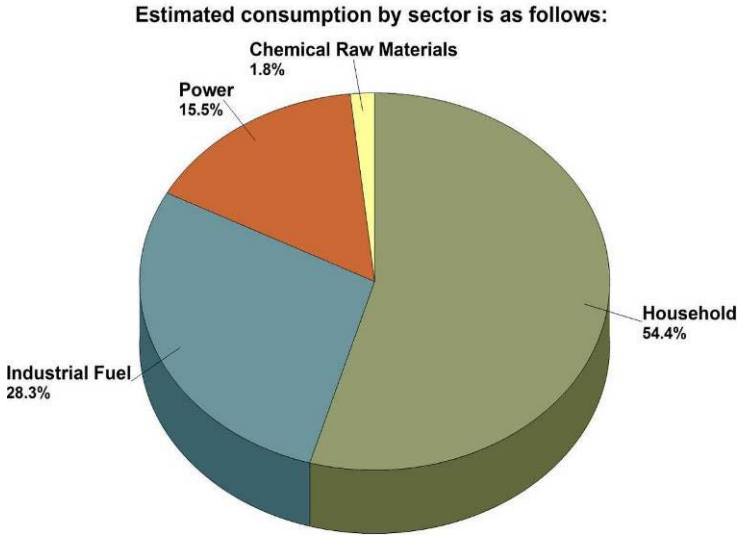


**FIGURE 31: CONSUMPTION OF SINOPEC GAS BY SECTOR**

*Burma-China Gas Pipeline*

In December 2008, CNPC signed a series of agreements with the Burmese government and a Daewoo gas production consortium to build an approximately 1,000 km, 10 billion cubic meter capacity pipeline to transport gas from two offshore blocks in the Bay of Bengal across Burma to Yunnan and Guizhou Provinces in China's southwest. Unofficial reports suggest that the route of the pipeline has yet to be finalized as of early 2009, and that gas is projected to start flowing to China in 2012-2013. CNPC has already negotiated preliminary offtake agreements with local distribution companies in the provinces (shxb.net, 2008).

The new pipelines described above will extend the national network into virtually all provinces of China. But there will likely remain small-medium sized cities within these provinces that will not be tied into the local distribution grids, and many of the larger cities will not receive sufficient gas to fully cover their residential populations.

### 5.1.3 China's Natural Gas Prices

#### *5.1.3.1 Upstream, Pipeline, and LNG Import Pricing*

The price of natural gas in China is regulated by both the central and local governments. Rather than set by supply and market demand, natural gas prices are determined largely on the basis of production, transportation and distribution costs, often (but not always) with some allowance for a rate of return on investment. Prices are almost completely delinked from the international gas price and the prices of other forms of energy in China. Currently, China has three types of gas prices: wellhead price, city gate price and consumer price. The wellhead price is the price at which the gas producers sell to the

long-distance transmission companies and is set by NDRC. The city gate price is the wholesale price set between the transmission and the municipal gas companies; it also is regulated by the NDRC.

The consumer price is the price at which the municipal gas companies retail their gas to the various end users, set by the different municipal companies. The consumer price varies with the category of consumers and depends largely on their perceived ability to pay, rather than the costs of supply.

The Chinese central government, through the NDRC, still controls well-head and pipeline prices from the major gasfields operated by CNPC and Sinopec. Traditionally, the government has striven to ensure cost recovery and modest returns to producers while containing costs to consumers as much as possible. It now wishes to change towards more market-driven pricing, but is doing so only gradually to avoid shock.

In large part, the government determines the price of natural gas on a cost-plus basis, with variations by sector. Consequently, natural gas prices in China often deviate from those on the international market. When China was still self sufficient in natural gas production, this price regime was effective in developing China's natural gas market. However, controlled pricing is less viable now that China's LNG and pipeline gas imports are growing rapidly. It also can lead to distortions where some petrochemical plants produce too much output based on controlled low natural gas fuel prices, which can be much less than those for oil.

Although some price rationalization has occurred in recent years, the Chinese government still controls the price of natural gas in most markets. China has been raising gas prices rapidly since LNG imports began in 2006 and is expected to continue increasing gas prices. However, domestic gas prices remain significantly lower than international prices. In 2006, when the first LNG regasification terminal in Guangdong was completed, for the first time China`s natural gas market was linked with the international market. Until recently the differential between domestic and international prices has been limited because China's gas imports are still small, but with imports growing rapidly it is likely that China's gas prices will rise towards international levels.

In December 2007, NDRC reformed and simplified the natural gas pricing system, establishing a more market-oriented price mechanism for China's gas industry. The principal changes made to China's natural gas pricing policy were as follows:

- Fewer Price Categories. Price categories were simplified by reducing the numerous categories used previously to only three categories: urban, fertilizer, and industrial. Fertilizer plants pay the lowest city-gate price, industrial users generally pay an intermediate price, while urban end-users pay the highest prices (**Table 31**).
- Shift to Guidance from Direct Control. In addition, NDRC moved from a mix of government-set gas prices with some government guidance (for gas sold within the allocated quota) to a more flexible approach of simply government guidance alone (for gas sold above the quota). The government-set price represents the city-gate price including well-head price and pipeline transportation tariff, which were set by NDRC. The government guidance price indicates that city-gate prices can fluctuate within a certain range based on the government-set price.
- Linkage to Other Fuels. NDRC also linked the wellhead gas price with the prices of alternative fuels, establishing a market-oriented price mechanism. As a result, the wellhead price rose in direction (but not magnitude) with the prices of crude oil, LPG and coal (basket weighted 40:20:20). The maximum year-on-year adjustment is 8 percent. The reference oil price is a weighted freight-on-board (FOB) price of West Texas Intermediate (WTI), Brent and Minas crudes. LPG

reference prices are FOB prices in Singapore. Coal reference prices are the average price delivered to Qinghuang Island from Shanxi (Datong's high-grade) and Shanxi (thermal coal).

**TABLE 31: NATURAL GAS PRICES ACCORDING TO END USER CATEGORY. SOURCE: NI (2007)**

| $4.15 = 1 RMB/m3 | End User Category | Gov't Set City Gate Price (RMB/m3) | ($/Mcf) |
|---|---|---|---|
| Sichuan - Chongqing | City Gas | 920 | $3.81 |
| | Fertilizer | 690 | $2.86 |
| | Industrial | 875 | $3.63 |
| Changqing (Ningxia) | City Gas | 770 | $3.19 |
| | Fertilizer | 710 | $2.94 |
| | Industrial | 725 | $3.01 |
| Qinghai | City Gas | 660 | $2.74 |
| | Fertilizer | 660 | $2.74 |
| | Industrial | 660 | $2.74 |
| Xinjiang | City Gas | 560 | $2.32 |
| | Fertilizer | 560 | $2.32 |
| | Industrial | 585 | $2.43 |
| Liaohe, Zhongyuan (Henan) | City Gas | 830 | $3.44 |
| | Fertilizer | 660 | $2.74 |
| | Industrial | 920 | $3.81 |
| West-to-East Pipeline | City Gas | 1270 | $5.27 |
| | Fertilizer | 1120 | $4.64 |
| | Industrial | 1100 | $4.56 |

Delivered gas prices can vary significantly across China's diverse gas fields, depending both on geography as well as the type of end user and its ability to pay. For example, even after the 2007 deregulation decree, the price of natural gas delivered to fertilizer plants in western China's Xinjiang region was as low as 0.56 RMB/cubic meter ($2.32/Mcf), whereas the gas price sold off the West-East Pipeline to city gas markets in eastern China was much higher at 1.27 RMB/cubic meter ($5.27/Mcf; Table 3-2). Since 2007 gas prices have been rising by about 8 percent per year, based on continued strong economic growth in China, and are expected to increase further in coming years as incomes rise.

After the latest increases in May of 2010, wellhead prices ranged from 0.8 to 1.5 RMB per cubic meter (approximately $3.2 - $6.1 per mmbtu), depending on the field and the end-use, with residential consumers and fertilizer plants enjoying the most favorable prices. When pipeline costs are added in, the city-gate prices to the major eastern cities range from approximately 1.5 – 1.8 RMB per cubic meter (NDRC, 2010; NDRC, 2003).

Coalbed methane prices are theoretically not subject to NDRC regulation and can be negotiated between the buyers and sellers. But when CBM is supplied through long-distance transmission pipelines, the regulated (lower) natural price in the same areas is normally used as the reference for negotiating and determining the CBM price. LNG prices are the most unregulated, being freely negotiated between the sellers and the buyers at every stage. As of 2010, the NDRC has chosen not to regulate the prices charged by small onshore LNG producers, such as those owned by coalbed methane producers in southeastern Shanxi Province. These producers are free to sell to local distribution companies in underserved areas and in the southern provinces for which the price has been driven by imported LNG.

City-gate prices on the Southeast coast for LNG imported under the first long-term contracts in the early 2000s were approximately 1.65 to 2.0 RMB per cubic meter ($6.75 – 8.15/mmbtu) (Guangdong News Net, 2007; Fujian Contract, 2007). Landed prices for LNG imported under more recent contracts from Qatar and other suppliers are as high as 3 RMB per cubic meter ($12 /mmbtu), which would raise city-gate costs to at least 3.5 RMB per cubic meter ($14/mmbtu)(Trading Markets 2009) .

Gas imported through the international pipelines will have a comparable price impact in broad areas across China. Reports indicate that the Chinese border price for gas imported through the newly commissioned pipeline from Turkmenistan will be 2.2 RMB per cubic meter based on $68 per barrel oil, and that average city-gate delivery costs in the heartland will be in the vicinity of 3 – 3.2 RMB per cubic meter (Chinagate, 2009). This implies a price of at least 3.5 RMB per cubic meter ($14 per mmbtu) city-gate in Guangdong and Guangxi Provinces in the south.

Delivered prices for Burma offshore gas transported to the southwestern provinces of Yunnan, Guizhou, and Guangxi, while higher than domestic gas prices, are not likely to be as high those for Central Asian gas due to shorter transport distance. CNPC will reportedly acquire the offshore gas from the Daewoo Production Consortium at a benchmark price of $7.73 per mmbtu (1.9 RMB per cubic meters), a figure that excludes all pipeline costs in both Burma and China (BusinessWorld, 2010). CNPC is reported to have promised that retail prices in the Yunnan provincial capital of Kunming "should not exceed 3.5 RMB" per cubic meter (Kunming News 2009). This implies a city-gate price of approximately 2.5 to 3 RMB per cubic meter in Kunming based on typical mark-ups by distribution companies, and perhaps 2.8 – 3.0 RMB in Guizhou.

City-gate prices to medium-sized cities in Guangdong and other eastern provinces which depend on LNG imported either on the international spot market or produced by the domestic small scale plants have been highest of all at as much as 3.5-4 RMB per cubic meter (Zhanjiang, 2009). The price for the limited volumes of domestic small-plant LNG price to Guizhou, by contrast, appears to have averaged approximately 2.5 RMB per cubic meter (Chemnet, 2009, & private sources).

#### *5.1.3.2 Retail Prices*

Local distribution companies offer a wide variety of ownership, ranging from offshoots of the upstream majors to local government companies to private companies of both national and local scope. Provincial and municipal governments, rather than the central government, regulate retail prices charged by the distribution companies.

At least thus far, price has not been a deterrent to household natural gas consumption. This is in part a function of price controls at both the wholesale and retail level that have kept the price to consumers in much of the country in the range of 2 – 2.5 RMB per cubic meter ($8.16 – 10.20 per mmbtu assuming 38,000 kilojoules per cubic meter and 6.8 RMB per dollar), competitive with the prices of competing fuels such as coal gas and liquefied petroleum gas. But residential consumers in some southern coastal cities and even certain small interior cities have paid up to 3.5 – 4.5 RMB per cubic meter ($14.27 -

$18.36 per mmbtu), reflecting local scarcities and high costs of imported LNG in 2007-2008. Assuming a per household consumption of approximately 230 cubic meters per year as is the case at present in Chongqing, these price levels translate to 805 – 1035 RMB ($118 - $152) per household per year, which remains a relatively small percentage of urban disposable income.

### 5.1.4 Demand for Natural Gas for Vehicle Use (CNG)

The number of civilian use motor vehicles in China was 64.67 million vehicles at the end of 2008, up 13.5 percent from the previous year. Of this overall total, which includes cars, trucks, and farm equipment, some 24.38 million were cars (up 24.5 percent). This large increase in vehicular traffic is a major cause of .increasing pollution problems in many of China's cities.

Consequently, both the central and local governments are promoting the use of CNG as an alternative vehicle fuel, as one way to reduce pollution levels. CNG vehicles emit 90 percent fewer particulate emissions than diesel or gasoline powered vehicles, with significant reductions in carbon monoxide and nitrous oxide emissions. Greater use of CNG in transportation also could help slow China's oil import growth.

At current gasoline prices, which due to continued price increases by the Chinese government are currently about 25 percent higher than in the U.S., it can be up to 40 percent cheaper for Chinese consumers to fuel their vehicle with CNG rather than gasoline and diesel. The costs to convert a car to run on CNG fuel, rather than gasoline, can be as low as RMB 1700 ($250). The number of CNG filling stations in China is increasing, but their distribution is constrained by their distance from the CNG processing plant, which in turn is generally located close to a suitable methane source, whether it is a natural gas field or pipeline, or a CBM/CMM project. The central government is encouraging the building of new CNG filling stations, and in the latest economic stimulus plans has included incentives such as a fast-track approval process and credit support from lending institutions.

### 5.1.5 Demand and Pricing for LNG

In parallel with the growth of China's natural gas pipeline system, LNG production and consumption also are growing rapidly. Large-scale LNG expansion continues, with the new Guangdong and Fujian LNG Terminals along the east coast having started up in 2009, with annual capacities of 3.7 and 2.6 million tonnes, respectively. Several additional large LNG import terminals are planned to start within the next few years. In addition, there are increasing numbers of small-scale LNG prod uction facilities throughout China that offtake natural gas from pipelines and then convert it to LNG for local/regional transport and use.

The key advantages of LNG include that it can be transported flexibly over varying distances to relatively small demand centers that are spread over a wide geographic area. In addition, LNG can be stored where needed in relatively large volumes to allow for daily or weekly fluctuations in demand. In China,

LNG is particularly competitive because only a small number of cities are connected or adjacent to the existing gas transmission pipelines.

The potential consumers of LNG include: (a) municipal and town gas companies which have no access to the gas transmission system; (b) large industrial and commercial establishments which are not connected by pipeline; and (c) municipal gas companies which are connected to the pipeline system, but which require storage of LNG to meet fluctuating gas demand. Despite the growth in China's gas pipeline system, it will be decades before all Chinese towns and cities are connected through an extensive pipeline system. Therefore, LNG is likely to retain a share of the market for some time (World Bank, 2009).

Another significant advantage of LNG is that its prices are the most unregulated, being freely negotiated between the sellers and the buyers at every stage. Thus, LNG prices can be significantly higher than other more regulated natural gas prices.

Recently, small-size inland LNG producers operated by private companies, such as Fortune Oil PLC, also are emerging. In Xinjiang, for example, a new private company recently built a small LNG plant with production capacity of 0.6 billion cubic meters/year (432,000 t/year), with delivery of LNG by tanker trucks. Such a flexible business can makes sense for inland and rural consumers.

### 5.1.6 Central Government Natural Gas and CMM Policy

The central government has been strongly motivated by the local and global environmental advantages of natural gas to increase its percentage of the energy mix relative to other fuels. The country's 11$^{th}$ Five-year plan (2006-2010) calls for natural gas to rise from 2.8 percent of total primary energy consumption in 2005 to 5.3 percent in 2010, and for coal to fall from 69.1 percent to 66.1 percent (NDRC, 2006.3).

But even with 19 percent annual growth in natural gas consumption during the period, the natural gas share of total energy consumption barely exceeded 4 percent in 2010 due to continuing double digit increase in coal consumption. The continued construction of large numbers of coal fired power plants in particular has created a structural barrier to a lesser reliance on coal in the short term. (China Energy Bureau 2011, CESY 2010 p. 52). As of 2007, gas had only risen to 3.4 percent of the national primary energy total. This represented a failure to contain growth in coal consumption during years of double digit economic growth led by energy intensive heavy industries, rather than any slowdown in gas development. Possibly, as coal consumption moderates in reaction to heavy industrial slowdown starting from second half of 2008, the gas ratio of primary energy will rise at a more rapid rate in coming years.

Government sources have expressed the hope of increasing the percentage of primary energy coming from natural gas to 8-10 percent by 2020. Even if this optimistic target were to be achieved, the natural gas share of China's total energy would still fall short of the 23-25 percent level prevailing at present in the United States and the European Union.

A white paper issued by NDRC in August 2007 outlines in some detail the sectors in which natural gas substitution for other fuels is most encouraged:

- Cooking and hot water heating for urban residents
- Use in government offices, commercial enterprises, and public facilities
- Transport/automotive (compressed natural gas)
- Distributed district heating/air conditioning

Second tier priorities include:

- Centralized space heating and air conditioning in big cities, as well as individual residence space heating.
- Substitution of natural gas for petroleum products or coal gas as an industrial fuel.
- Peak regulation power stations in areas where natural gas is readily available.

In a break with over 30 years of previous government policy, the NDRC white paper recommends sharply curtailing construction of new chemical fertilizer plants using natural gas as a raw material, and for completely banning new natural gas-derived methanol plants (NDRC, 2007.5).

In China, the central government owns all rights to CMM. CMM is considered an associated mineral of coal, so CMM rights are included with coal exploration and production. For CDM projects, foreign ownership is limited to 49 percent and the central government requires 2 percent of carbon credits as a fee (Franklin, 2010.1).

In June of 2006, China's State Council issued *Opinions on Speeding up CBM/CMM Extraction and Utilization* which requires that local land and planning authorities ensure that coal mines implement a safety first approach that focuses on accident prevention, safety standards and oversight by the government, and the use of technology when extracting gas prior to coal mining (IEA, 2009).

The rules governing the permitted concentration of methane in air in most countries are driven by the physical properties of gas mixtures of methane in air. Common international practice prohibits the transportation and utilization of gas mixtures within the explosive range (5 percent to 15 percent) including a safety margin. These limits are country specific and range from 1 percent to 25-30 percent of methane in air under ambient conditions (UNECE, 2008).

China has conflicting regulations regarding methane concentration. Over 70 percent of the recovered CMM in China has a concentration of less than 30 percent (IEA, 2009.1). China's Ministry of Environmental Protection established an emission standard for CBM / CMM in April of 2008 that prohibits emission of methane from CBM/CMM drainage systems and specifies that CMM drainage systems with greater than 30 percent methane concentration must use or flare the gas, potentially causing mines to maintain gas concentrations below 30 percent while ignoring best practices and safety standards.

In April of 2007, NDRC issued *Notice on CBM/CMM Price Management* to increase CMM output by addressing market barriers. The notice states that the price of gas that is not distributed via city pipeline networks can be determined freely through negotiations. The price of gas distributed via city pipeline networks and operations under government control are to be determined according to the heating value of the gas as compared to substitute fuels such as natural gas, coal gas and liquefied gas.

NDRC also issued the *Notice on Executing Opinions on Generating Electricity with CBM/CMM* which encourages the deployment of power generation projects with CBM/CMM. The notice requires that electricity generated by CBM/CMM power plants is given priority by grid operators who purchase surplus electricity at a subsidized price. CBM/CMM power plant owners are also exempted from market price competition and do not undertake any responsibilities for grid stability. This notice has not been observed in practice, however.

China's Ministry of Finance issued *Executing Opinions on Subsidizing CBM/CMM Development and Utilization Enterprises* whereby any enterprise engaged in CBM/CMM extraction within China is entitled to financial subsidies if the gas is used on-site, marketed for residential use, or marketed as a chemical feedstock. CBM/CMM used to generate power does not receive this subsidy (IEA, 2009.1).

As a participant in the CDM, China is host to many emission reduction projects; however, a low number of projects have been registered by the CDM Executive Board, which questions the role of carbon credits from this sector as a major source of supply. Additionally, not only is the registration quota poor, so is the number of total projects submitted for registration, given the large volume of methane emissions from coal mines. China is host to over 40 CMM projects registered as CDM projects and 64 total operating CMM projects. Other large CMM markets are mainly Joint Implementation (JI) countries. With the exception of a few projects, the Chinese CMM market is dominated by a "do-it-yourself" approach with international companies acting as buyers of Certified Emission Reductions (CERs) but with those companies having limited influence on project execution and operations. If a coal mine operator is not funding and managing the CMM project properly, the project is could be delayed, postponed or fail to be implemented.

Further, as noted above, an alarmingly high 70 percent of China's drained CMM is at or near the explosive range. Utilization of this methane is either not feasible, when adhering to international safety standards, or unreliable, due to complications in safely transporting and handling explosive gas mixtures when in default of such standards. Also, regulations requiring use of high quality methane call into question the additionality from the CDM perspective of high-quality CMM recovery and utilization projects. Another challenge to CDM projects is that some project design documents lack consistency and clarity, leading to a more time-consuming project review process (UNECE, 2008).

China has a number of programs in place that have built capacity in the way of reducing CMM emissions. The USEPA assisted in the development of the China Coalbed Methane Clearinghouse beginning in 1994. In addition, the Guizhou Coal Mine Methane Initiative promotes CMM recovery and utilization among gassy coal mines in Guizhou Province, China. The project began when the Guizhou International Cooperation Center for Environmental Protection received a grant from USEPA in support of its Methane to Markets Program.

## 5.2 Anhui

*Pipeline Network and Consumption Volumes*

Anhui Province has no known gas deposits. It began to use natural gas in limited quantities with the completion in 2004 of CNPC's first West to East pipeline, which passes through the northern part of the province in a Northwest to Southeast direction en route from Zhengzhou to Nanjing through Lixin County, Dingyuan County, Bengbu City and Chuzhou City.

The CNPC concurrently built branch pipelines from the Dingyuan County transfer station to the provincial capital in Hefei, and from Nanjing southwest along the southern bank of the Yangtze River through the major steel center of Maanshan to Wuhu City. The Anhui Provincial gas company added a series of smaller branch pipelines from transfer stations on the main line to Fuyang, Huainan, Suzhou, and Huaibei cities, and extended the Wuhu branch further along the Yangtze to Tongling.

Through 2008, the above-mentioned facilities accounted for the entirety of provincial consumption shown in **Table 32** below. The rapid jump in 2009 and 2010 usage represented not only shipments through the West to East pipeline, but also the commissioning of the 12 million ton per year Sinopec Sichuan – Shanghai pipeline which runs across southern Anhui from Anqing in the west to Xuancheng in the east near the Zhejiang border.

**TABLE 32: ANHUI NATURAL GAS CONSUMPTION, 2005-2010 (MILLION CUBIC METERS)**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Consumption | 85 | 195 | 403 | 714 | 977 | 1500 |

Source: CESY, 2010, p. 90; Anhui Energy Administration, 2011

A branch from Xuancheng to Nanjing passes through some of the same Yangtze River cities as the Nanjing – Wuhu branch of CNPC's West to East pipeline. The so-called "North of the River Connector Line" with approximately 500 million cubic meter capacity is being built north from Anqing to Hefei, where it will link in 2011 – 2012 to the CNPC branch line, thus creating the beginnings of an integrated network in the province.

*Consumption Patterns*

Hefei accounted for somewhat over 200 million cubic meters, or about 14 percent of total provincial consumption in 2010. It is unlikely that any other single locality consumed as much as Hefei given constraints on supply and branch pipeline capacity (Anhui News, 2011.1).

Sectorally, industry accounted for the largest share of natural gas use in 2009 (**Figure 32**), but not by as wide a margin as is typical in the rest of the country. Limitations in supply and supporting infrastructure could be a reason for this. The amount used in transportation, which rose from almost nothing in 2007 to over 10 percent of the total in 2009, reflects the rapid popularization of compressed natural gas (CNG) as an inexpensive automotive fuel. The NDRC is demanding that all local authorities in China raise CNG prices to a minimum of 75 percent of gasoline prices in order to discourage overconsumption of natural gas in motor vehicles.

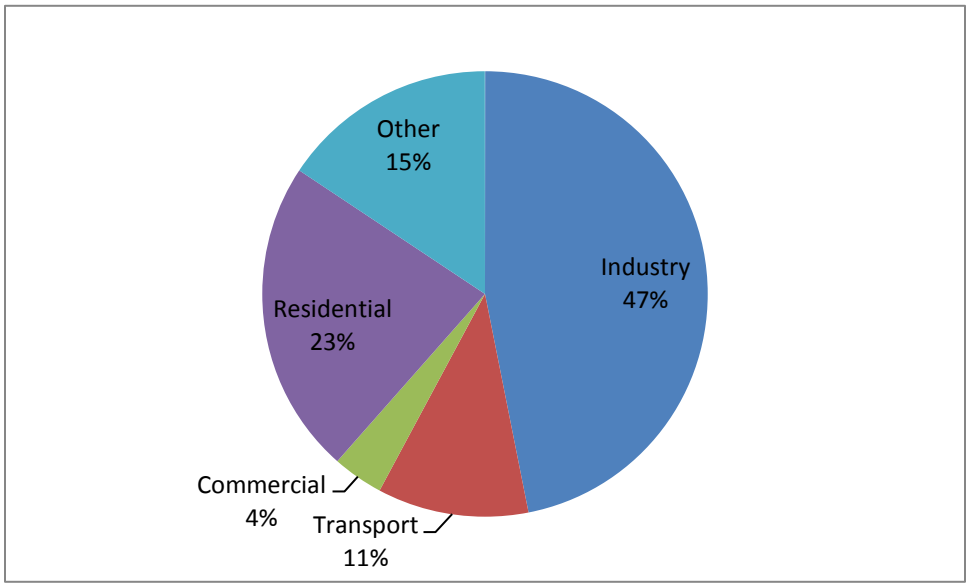


**FIGURE 32: ANHUI CONSUMPTION OF NATURAL GAS BY SECTOR, 2009. SOURCE: CESY 2010. P. 169.**

*Future Trends*

Gas supply will be the principal constraint on future consumption growth in Anhui. It is reported that the central government has only allocated 800 million out of the 12 billion cubic meter throughput of the Sichuan- Shanghai pipeline to Anhui, and it is unlikely that the figure is much higher than 1.5 billion cubic meters for the first West to East pipeline, which suggests a ceiling of perhaps 2.5 billion cubic meters until additional gas sources are developed (China Securities Journal, 2010).

Anhui is not an important destination for Central Asian gas transmitted through the CNPC's Second West to East pipeline starting from 2010. One branch of the pipeline passes through Dangshan County in the northernmost sliver of the province, but no infrastructure is being built to get large volumes of Central Asian gas to major potential consumption centers (Anhui News, 2008). The main positive impact of the new pipeline for Anhui will be to put more gas in the increasingly integrated national pipeline network, possibly freeing up some gas from other sources for Anhui.

*Pricing*

**TABLE 33: WHOLESALE PRICING TO THE MAIN CNPC/SINOPEC TRANSFER STATIONS IN ANHUI (YUAN/CUBIC METER)**

| | Wellhead | Pipeline shipment | Total |
|---|---|---|---|
| CNPC Xinjiang gas, first West to East Pipeline | | | |

| | | | |
|---|---|---|---|
| 1) Residential Use<br>2) Industrial Use | 0.79<br>1.19-1.215 | 0.75<br>0.75 | 1.54<br>1.965 |
| Sinopec Sichuan gas, "Sichuan to East Pipeline" (all uses) | 1.51 | 0.65 | 2.16 |

Source: NDRC 2003; NDRC 2009.1; NDRC 2010.2

### 5.2.1 CMM Market and End-Use Options

SDIC-Xinji Energy has evaluated the villages close to the Liuzhuang mine but does not consider any to be viable end-users for CMM produced at the mine. Currently, these villages utilize either agricultural waste (straw) or waste coal for heating. The coal also tends to be low-quality coal supplies that are mined locally but not considered viable for transport outside the Liuzhuang area due to poor quality. This waste coal is abundant and quite inexpensive. Liuzhuang CMM would need to be sold at an extremely low price to displace this waste coal, certainly much lower than its alternative value for more profitable utilization approaches, such as power generation.

According to the Huainan government, Huainan Municipality as a whole consumes 120,000 cubic meters of natural gas per day, or approximately 44 million cubic meters per year. Only 180,000 of the city's over one million urban residents are connected to gas (one third of these 180,000 burn coalmine methane), and there are only 6 industrial enterprises burning natural gas, so there is obviously potential for wider use (HMFA, 2011).

Given the limits of the small 17.4 km pipeline connecting CNPC's West to East trunkline with Huainan, this suggests that there should in principle be demand for SDIC-Xinji's gas in Huainan generally, beyond the immediate mining area. The mine's ability to either connect to the Huainan local gas distribution network or to sell LNG to an unloading terminal will depend on the local gas company's logistical ability to construct the necessary infrastructure, which cannot be taken for granted in view of the fact that the utility is losing money.

Considering the limitations in natural gas supply to Anhui as a whole, there should certainly be demand for Huainan's purified CMM in other cities in Anhui, if not in Huainan. The mine's capability to sell, however, will undoubtedly depend on the price it charges.

As noted above in **Table 33**, the wholesale prices charged by the local gas distribution companies to CNPC and Sinopec range from 1.54 yuan per cubic meter for Xinjiang gas used as residential fuel (as in Huainan) to 1.965 yuan per cubic meter for Xinjiang gas used for industry to 2.16 yuan per cubic meter for Sinopec Sichuan gas for all usages (inclusive of tax).

Unless the shortages of gas in Anhui become so acute that local governments become willing to pay higher market prices, 2.16 yuan per cubic meter per the Sinopec Sichuan gas wholesale cost is a reasonable reference price for Huainan gas in the Anhui market. Despite the high transport costs, Anhui coal mines might be able to earn a higher return by sending LNG to markets in areas such as Guangdong in southern China where local wholesale prices are 3 yuan per cubic meter or higher.

## 5.3 Chongqing

Chongqing has one of the oldest and best-developed natural gas distribution infrastructures in the entire country due to its proximity to the Sichuan gasfields. Its total natural gas consumption reached a reported 4.5 billion cubic meters in 2007, putting it in the top three provincial consumers on a per capita basis, with 14 percent per year average growth from 2004-2007.

The Chongqing Gas Group, a subsidiary of CQEIG, has the franchise for gas distribution in the core Chongqing metropolitan area, as well as in a number of the outlying counties and cities, and accounted for approximately one third of Chongqing's gas consumption in 2007. Most of the remainder was purchased directly from PetroChina by large industrial enterprises, with a small amount going to smaller distribution companies in some of the outlying areas (including some owned by PetroChina itself).

Chongqing Gas projected in 2007 that its sales would increase by at least 500 million cubic meters by 2010, with demand being driven by gradual expansion of the residential coverage base from 1.63 million customers (approximately 5.25 million people altogether) to 2.1 million customers (6.8 million people), as well as by continued industrial growth (**Table 23**).

**TABLE 34: CHONGQING GAS CONSUMPTION (MILLION CUBIC METERS)**

| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|
| **Chongqing Gas Group** | 860 | 965 | 1250 | 1482 | 1700 | NA | 2400 |
| **Industrial** | 168 | 207 | 296 | 346 | 406 | 446 | 467 |
| **Residential** | 236 | 262 | 341 | 371 | 421 | 466 | 510 |
| **Commercial** | 37 | 51 | 78 | 100 | 131 | 171 | 215 |
| **"Independent networks"** | NA | NA | NA | 268 | NA | NA | NA |
| **Automotive CNG** | 101 | 142 | 174 | 240 | 245 | 276 | 344 |
| **"Collective" (public)** | NA | NA | NA | 45 | NA | NA | NA |
| **"Non-industrial boilers" (heating/air conditioning)** | NA | NA | NA | 52 | NA | NA | NA |
| **Loss** | NA | NA | NA | 60 | NA | NA | NA |
| **Subtotal** | NA | NA | NA | 1482 | NA | NA | 1536 |
| | | | | | | | |
| **Direct Purchase by Industry/ Other Distribution Companies** | **2174** | **2585** | **NA** | **3018** | **NA** | **NA** | **7242** |
| **Total** | **3034** | **3550** | **NA** | **4500** | **NA** | **NA** | **9642** |

Source: Chongqing Gas Group, Chongqing Energy Investment Company

Precisely because of its proximity to the gas source and because of its long history of gas use, however, Chongqing's regulated natural gas retail sales prices are among the lowest in China.

**TABLE 35: REGULATED NATURAL GAS RETAIL PRICES, CHONGQING MUNICIPALITY, DECEMBER 2008**

| End-use Category | Price: (RMB/cubic meter) |
|---|---|
| Industrial user: | 1.67 |
| Residential: | 1.40 |

| | |
|---|---|
| Commercial: | 2.21 |
| Automotive CNG (to gas station): | 1.17 |

Source: Chongqing Gas Group, Chongqing Energy Investment Company

### 5.3.1 Regional Natural Gas Demand

#### *5.3.1.1 Residential Sector*

In the municipality of Chongqing, households connected to gas consumed an average of 70 cubic meters per connected resident per year in 2007. Projected across the approximately 475 million unconnected city and town dwellers, this implies unmet urban residential demand in the vicinity of at least 33 billion cubic meters per year.

This figure does not factor in either the use of natural gas for space heating in colder parts of China (little gas is used for space heating in Chongqing homes), or increasing urbanization over time; the current national urbanization ratio is reported to be 43.9 percent of the national population, with growth in the vicinity of 1 - 1.2 percent per year. Nor does it include commercial consumption, which in Chongqing was an additional 27 percent in addition to residential consumption in 2007. When these additional factors are considered, it seems reasonable to assume that the level of unmet demand in the residential/commercial sector combined is at least 50 billion cubic meters nationally.

#### *5.3.1.2 Automotive Sector*

In Chongqing, where gas is relatively abundant, the automotive sector accounted for over five percent of total gas consumption in 2007; virtually all taxicabs in the city operate on compressed natural gas.

### 5.3.2 New Supply

Almost all of the spectacular growth in supply over the last 3-5 years has come from domestic sources, in particular the newly developed Tarim gasfield in Xinjiang (the major gas source for the West to East pipeline), and from the Changqing gasfield in western Inner Mongolia and Shaanxi provinces (the gas source for the pipelines to Beijing). There are already signs, however, that growth from these fields is slowing. National output in 2008 is reported to have grown by 6.5 – 7 billion cubic meters in 2008, compared to almost 11 billion in 2007 and over 9 billion in 2006 (**Table 25**). Output from Xinjiang grew by 3 billion cubic meters in 2008 compared to 4.5 billion in 2007, and almost 6 billion in 2006. See **Table 36** and **Figure 26.**

**TABLE 36: CHINA NATURAL GAS PRODUCTION BY PROVINCE (BILLION CUBIC METERS)**

| Provinces and Municipalities | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|
| ***North*** | | | | |
| Beijing | NA | NA | NA | NA |
| Tianjin | 879 | 1,050 | 1,334 | NA |

| Provinces and Municipalities | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|
| Hebei | 692 | 655 | 714 | NA |
| Shanxi | 324 | 602 | NA | NA |
| Inner Mongolia | 1,719 | 5,307 | 7,050 | NA |
| ***Northeast*** | | | | |
| Liaoning | 1,172 | 1,194 | 872 | NA |
| Jilin | 540 | 241 | 522 | NA |
| Heilongjiang | 2,443 | 2,452 | 2,550 | NA |
| ***East*** | | | | |
| Shanghai | 604 | 564 | 507 | NA |
| Shandong | 925 | 855 | 784 | NA |
| ***Central-South*** | | | | |
| Henan | 1,762 | 1,868 | 1,576 | NA |
| Guangdong | 4,475 | 4,894 | 5,247 | NA |
| Hainan | 166 | 205 | 203 | NA |
| ***Southwest*** | | | | |
| Chongqing | 327 | 647 | 500 | NA |
| Sichuan | 14,230 | 15,995 | 18,746 | NA |
| ***Northwest*** | | | | |
| Shaanxi | 7,546 | 8,047 | 11,010 | NA |
| Qinghai | 2,226 | 2,503 | 3,430 | NA |
| Xinjiang | 10,671 | 16,420 | 21,020 | 24,000 |
| **Total** | 49,300 | 58,539 | 69,310 | 76,000 |

Sources: CESY (2008), p. 41; NBSC (2008); ChinaGate December 11, 2008

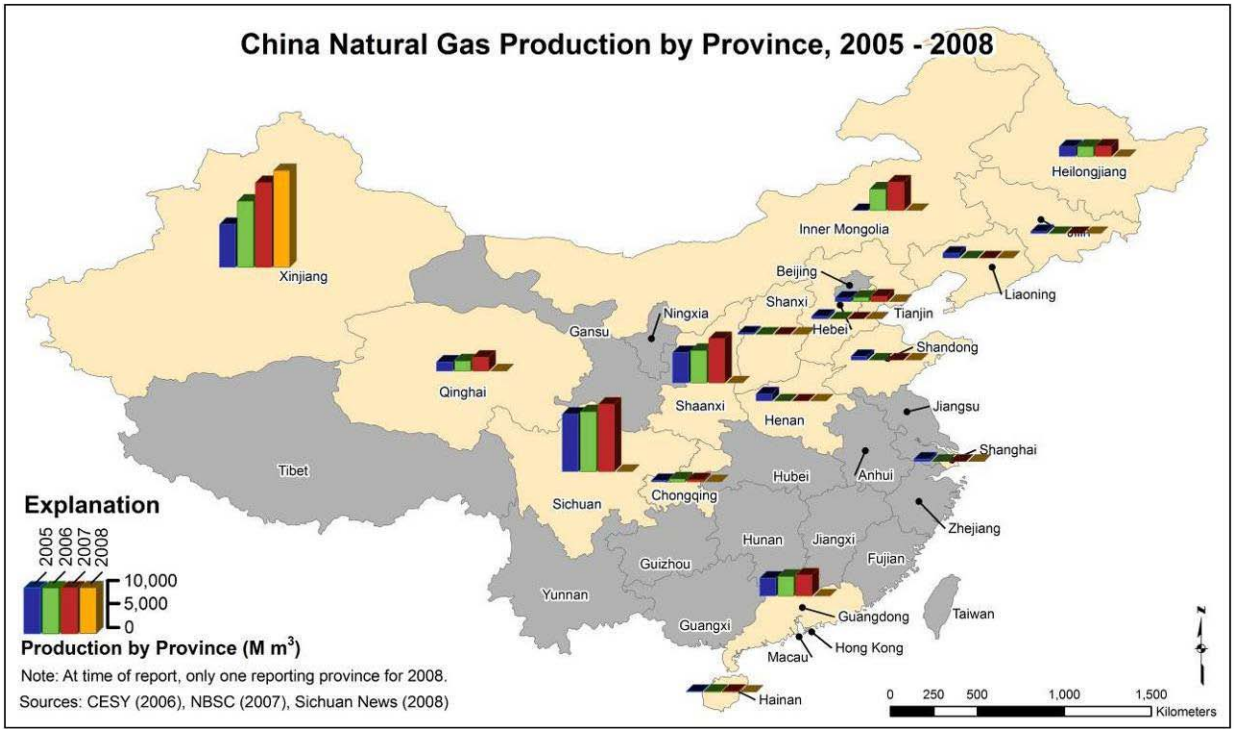


**FIGURE 33: NATURAL GAS PRODUCTION BY PROVINCE, 2005-2008**

The most important new domestic source of gas in the coming 3-4 years will be the Puguang field in Sichuan Province, just north of Chongqing, which is being developed by Sinopec, the smaller of the two state-owned onshore gas producers. Sinopec is building an 8 billion cubic meter per year pipeline from Chongqing to Shanghai, which is planned to allocate gas as shown in **Table 37** and **Figure 34** when it comes on stream in 2010.

**TABLE 37: SINOPEC GAS ALLOCATION BY PROVINCE**

| **Province** | **Allocation (million cubic meters)** |
|---|---|
| Jiangsu | 2,350 |
| Shanghai | 1,900 |
| Zhejiang | 1,850 |
| Anhui | 800 |
| Jiangxi | 300 |

Source: China Development Gateway Network, 2007

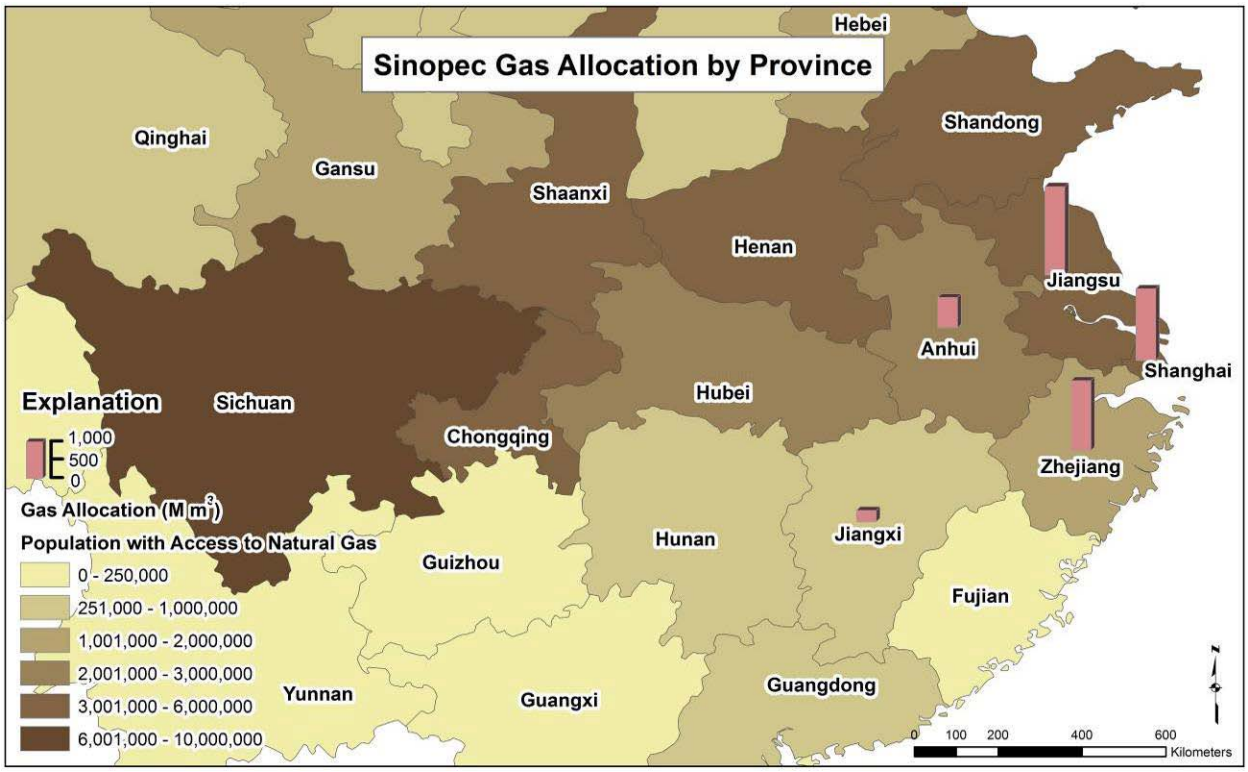


**FIGURE 34: SINOPEC GAS ALLOCATION BY PROVINCE**

An additional two million tonnes each will be allocated to Chongqing Municipality and Sichuan Province.

### 5.3.3 CMM Market and End-Use Options

The obvious target markets for CMM are underserved areas where there is no history of low retail prices. Guizhou Province to the immediate south of Chongqing is especially attractive geographically. Guizhou will receive no pipeline gas until the Burma-China pipeline is completed in 2012-2013, and is served at present only by small amounts of domestic LNG produced in Dazhou just north of Chongqing, and from Hainan Island (Guizhou Province Bureau of Commerce and Trade). Its capital city Guiyang and number two city Zunyi are located 283 and 133 km distance respectively from Songzao.

Guangxi Province is another possible target. It will receive no pipeline gas until the Central Asia gas pipeline is completed. Retail residential sales prices in Guilin (a major tourist city) and Nanning (the capital), both located approximately 950 km from Songzao, are 4 and 4.5 RMB per cubic meter, respectively (Guilin Evening News, 2009).

Most of the local distribution companies in the underserved areas that are prime CMM targets are controlled by major companies such as Xin'ao, China Gas or Hong Kong Gas. These companies have all expressed strong interest in LNG from SCEC. CQEIG will undertake a CMM purification and liquefaction project. The project is based on the "Feasibility Study of CMM Utilization for Songzao Coal and Electricity Company Coal Mines" on which Chongqing market information in this study is based. (See Section 7.3.1 for more details.)

## 5.4 Hebi Area of Henan Province

### 5.4.1 Regional Natural Gas Demand

*Production*

The state-owned giant Sinopec's Zhongyuan Oilfield centered in Puyang County in northern Henan has recovered natural gas since the mid 1980s. A series of small pipelines were constructed both to distribute the gas within Henan, and to transport it to neighboring Shandong and Hebei Provinces (China Transport Association).

Production peaked at approximately 2 billion cubic meters in 2003, and has been slowly declining since (**Table 38**). The field is not considered a promising source of natural gas for the future, and no other conventional gasfields have been discovered in the province.

*Consumption*

From the mid-1980s, cities in northern and eastern Henan consumed approximately 1-1.5 billion cubic meters per year of gas from Zhongyuan distributed through a series of small pipelines (CESY, 2006, p. 120). Consumption only began to rise appreciably with the completion in 2004-2005 of CNPC's first West to East gas pipeline which transverses the province en route from the Xinjiang gasfields of the far northwest to Shanghai. The arrival of gas from Xinjiang catalyzed the development of a rudimentary pipeline network within the province, (including branch lines from the entry point in Jiaozuo City east to Anyang, and from Zhengzhou south to Xinyang).

**TABLE 38: HENAN NATURAL GAS PRODUCTION AND CONSUMPTION, 2005-2009 (MILLION CUBIC METERS)**

| | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|
| Production | 1,762 | 1,868 | 1,576 | NA | 1,000 |
| Consumption | 2,371 | 3,053 | 3,314 | 3,823 | 4,155 |

Source: CESY 2010, pp. 42, 90

By 2009, consumption had risen to 4.2 billion cubic meters, over three quarters of which originated in Xinjiang, accounting for approximately 20 percent of the Xinjiang – Shanghai pipeline's reported 17 billion cubic meter throughput. But while the province's 15 percent growth rate in natural gas consumption 2005-2009 kept pace with the national average, the growth rate fell below 10 percent in 2008 and 2009 as the Xinjiang pipeline approached its full capacity and Zhongyuan's production tapered off.

The clearest sign of constraints on consumption can be seen in **Table 39** and **Figure 35**, which show that residential consumption, which has been an important driver of national natural gas consumption, actually decreased from 2005 to 2009 as Henan gave first priority to industry and to electric power. The approximately 400 million cubic meters of natural gas consumed in Henan households only covered a small fraction of the province's almost 36 million urban residents.

**TABLE 39: HENAN COMPOSITION OF NATURAL GAS CONSUMPTION, 2005-2009 (MILLION CUBIC METERS)**

| | 2005 | 2007 | 2009 |
|---|---|---|---|
| Industry | 1,624 | 2,676 | 2,893 |
| Electric Power | 101 | 35 | 769 |
| Residential | 535 | 500 | 389 |
| Other | 111 | 103 | 104 |
| Total | 2,,371 | 3,314 | 4,155 |

Source: CESY 2010, p. 185; CESY 2008, p. 185; CESY 2006, p. 189

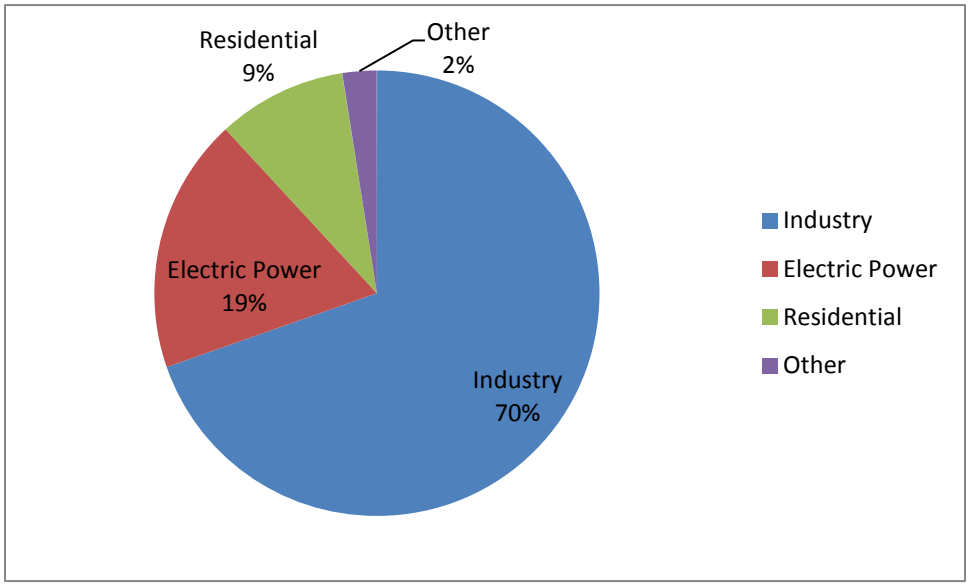


**FIGURE 35: HENAN COMPOSITION OF NATURAL GAS CONSUMPTION BY SECTOR, 2009**

*Future Growth*

Natural gas consumption in Henan will receive a significant boost in the coming 2-3 years with the completion of the following pipelines:

- A series of 6 branch pipelines with total capacity of 2.9 billion cubic meters, which will distribute gas from the CNPC's second "West to East gas pipeline" originating in Central Asia to most of the province's major cities (HPGMPCO, 2011).
- A 3 billion Sinopec pipeline from the northern Shaanxi gasfields passing through Henan to Jinan, the Shandong Province capital. As much as half of this gas will be consumed in Henan, transmitted through a major branch line running almost the breadth of the province from Anyang in the northeast to Luoyang in the west (Puyang Daily, 2010).
- A 1 billion cubic meter pipeline to transmit coalbed methane from Jincheng in Southeast Shanxi across the Henan border to Bo'ai (Jiaozuo DRC, 2011).

If Henan follows the projected national trend of 10% compounded growth in natural gas demand from 2010-2020, however, these new projects will only satisfy a small portion of what is required. If and when the Chinese natural gas production and transmission companies develop new gas sources in northwest China and Russia/Central Asia, Henan will undoubtedly receive its share. Land-locked,

however, it is unlikely to benefit from rapidly increasing LNG imports, which will become a significant source of gas for the coastal province in coming years. In principle, Henan will have the capacity to consume any purified CMM that is produced in-province.

*Gas Consumption and Infrastructure in the Vicinity of Hebi*

Although located only 70 km from the Zhongyuan oilfield, Hebi City has never been connected to the small pipeline network distributing Zhongyuan's gas. Natural gas first reached Hebi in 2005-2006 with the completion of a CNPC first West to East branch pipeline connecting Jiaozuo to Anyang through Xinxiang. As the maximum capacity of this pipeline is 630 million cubic meters, and the other cities on the route have their own claims on the throughput, it can be estimated that Hebi gets about 100 million cubic meters per year (People's Daily Net, 2003). Sinopec's Anyang to Luoyang branch pipeline noted above will also run through Hebi, with completion targeted for 2011-2012. Hebi will likely receive significantly more gas from this line, whose maximum capacity is approximately 1.5 billion cubic meters (China Natural Gas Equipment Web, 2010).

As it is unlikely that these lines will fully satisfy Hebi City's demand, Hebi could consider connecting its source of purified CMM to the Hebi Municipal distribution network. It could also negotiate with the owners to inject its purified CMM into either of the two transmission pipelines passing through Hebi. Reliability of supply, and especially pricing would be the key to success of such negotiations.

*Natural Gas Pricing in Henan*

The price increases of May 2010 fixed the city-gate prices in Henan for gas from the main first West to East CNPC trunkline were fixed at approximately 1.9 yuan per cubic meter for industrial users who account for the vast majority of consumption, and at almost 1.5 yuan per cubic meter for residential users. Transmission through the branch pipeline to Henan adds perhaps .1 yuan per cubic meter to this cost, bringing the estimated city-gate price at Hebi to 1.9 yuan weighted average (NDRC, 2003; NDRC, 2010.2).

While no price is known to have been published for the Sinopec pipeline from Yulin to Anyang City (the major terminus in Henan for the line extending to Jinan), it would be consistent with past patterns for the National Development and Reform Commission to establish approximate parity between the CNPC and Sinopec prices. Therefore, 1.9 yuan per cubic meter could serve as a reference for Hebi area wholesale prices at present.

CNPC's Second West to East pipeline has the potential to push the Henan natural gas price structure upward. Numerous unofficial reports suggest that the price to CNPC at the Kazakhstan-Xinjiang border of the Turkmenistan gas flowing through this pipeline is 2.0 – 2.2 yuan under its purchase contract with the producers (Chinagate, 2009). This is approximately 1 yuan per cubic meter higher than the fixed wellhead prices for CNPC's own Xinjiang production. If it is assumed that the NDRC fixes the pipeline prices to main transfer stations at the same 0.68 yuan per cubic meter charged for the first West to East pipeline, this translates into wholesale prices at the CNPC transfer station of approximately 2.7 – 2.9 yuan per cubic meter, which does not include further costs on branch pipelines (NDRC, 2003).

As of mid-2011, the NDRC has not yet agreed to a wholesale in-China price for Central Asian gas, and CNPC is being forced to sell at the existing prices for the first pipeline. CNPC has publicly complained that it is losing approximately 1 yuan for each cubic meter of Central Asian gas sold in China, and is applying pressure on the NDRC to allow it to recover its costs (Economic and Finance Net, 2011).

Assuming that NDRC ultimately bows to market forces, 3 yuan per cubic meter order of magnitude, or perhaps some weighted average of 3 yuan per cubic meter for “new gas” from Xinjiang and 2 yuan per cubic meter of “old gas” or “domestic gas” could become a new wholesale reference price for Henan.

Little if any of the Central Asian gas will reach the Hebi – Anyang area in the near term, however, as the trunk pipeline runs more to the south and west, and the known branch pipelines do not extend farther than Zhengzhou, approximately 200 km to the south of Hebi. It is possible, therefore, that the pipeline companies will be reluctant to pay for Hebi purified CMM at any more than currently prevailing wholesale prices. Given the difficulties they would encounter passing the prices through, Hebi might earn a better return shipping LNG to more distant southern markets than by selling into the local natural gas market.

### 5.4.2 CMM Market and End-Use Options

Hebi is a region of high demand for energy in all forms, which provides several possible markets for CMM. Firing boilers is a common use of CMM in China, but uses only a small percentage of extracted CMM. Demand from domestic users varies widely daily and seasonally and CMM is often vented during the summer months when it is not needed for heating. Some CMM drained from Chinese mines has been used for coal drying and this is a potential growth market as more Chinese coal is washed to meet increased coal quality standards.

Pipeline sales are an option in the Hebi area. Delivering gas straight to Hebi's city gate pays RMB 1.9 /cubic meter. As noted above, however, Hebi might earn a better return shipping LNG to more distant southern markets where wholesale prices exceed 3 yuan per cubic meter than by selling into the local natural gas market.

Many mines use Chinese-made reciprocating engines, especially designed to be fueled by low-concentration CMM, to produce electricity for the mine's use. The engines are relatively low cost, modular and can operate using varying amounts and concentrations of input gas. Heat exchangers on the generators can heat water for radiators or boilers. Power generation from CMM is generally considered less costly and less complex than sales-to-pipeline projects. National policies encourage sales to the grid of electricity generated using CMM, although policies are not widely enforced and local electric grid operators have ignored them in the past.

Mine shaft heating is a mandatory process in northern China to prevent ice hazards and protect miners during harsh winters. In warmer latitudes, gas powered air-conditioning units can be used to cool mine shafts. January temperatures in the Hebi area average -2°C and heat produced during power generation is an option for additional CMM energy recovery.

CMM of sufficient quality can be compressed to reduce its volume for transportation to available markets. CNG use is a growing market in China and it is popular as a vehicle fuel, especially in taxis and with bus fleets because CNG is up to 40 percent cheaper than gasoline (on a comparative scale). Most production is currently centered near producing gas basins or major pipelines, although some projects have used CBM as a feedstock. Jincheng City in Shaanxi Province, 100 km from Hebi, is a major source of CBM for a CNG processing plant which distributes CNG to central Henan Province.

LNG is used to fill the gap between China's ever increasing demand for natural gas and its lagging domestic supply. China began importing LNG in 2006 and import volumes have grown rapidly. Total imports are reported to have more than doubled between 2008-2009, with average imports of 12 million cubic meters per day in 2008 and the latest figures of 37 million cubic meters per day in 2009.

Over 60 percent of the imported LNG is used in new gas fired power stations, while the rest is distributed as town gas for residential and industrial end users. China also has almost a dozen domestic LNG plants in operation or under construction and leads the world in small scale LNG production. When the plants are all on-stream, they will produce between 6-7 million cubic meters per day, equivalent to 15-20 percent of current import volumes. As noted above, the Songzao CMM to LNG project is underway.

#### *5.4.2.1 Consumer Base in the Hebi Area*

Henan Province is China's most populous province, with an estimated 2007 population of 98.7 million (HSY, 2008). Hebi is a major industrial area with a large residential population. As such, there is a large demand for both electrical power and natural gas in the area and this demand is predicted to grow steadily at rates of 5-10 percent a year. Hebi City receives natural gas via a trunkline from the West-to-East pipeline and has a well developed gas distribution system. The city is supplied with electricity from a local thermal plant and major transmission lines from the regional grid. Hebi City is a transportation hub with good rail and road access to Beijing and the region's major cities.

*Industries*

Hebi is now a medium-sized industrial city and a transportation hub for northern Henan Province. With the development of a new industrial and technology area, spurred by the availability of nearby industrial mineral resources, the city's population has increased rapidly to over 1.4 million, while its 2007 GDP growth was 18.2 percent (HESDR, 2007).

Hebi's mix of light and heavy industries include agricultural products processing; coal mining and dressing; raw chemicals and chemical products; electronics and machine manufacturing; metallurgy; electricity and heat production and supply; and rubber products manufacturing. Proven dolomite reserves in the area are approximately 1 billion tons and source a local, energy intensive magnesium production industry. China now produces more than 60 percent of the world's magnesium.

The province leads the country in the production of grain and oil-bearing crops and is a big producer of cotton, meat, poultry and eggs, all of which lead to Henan Province being an important food processing base. The thriving agricultural sector means that 66 percent of the population resides in rural areas. The province also has extensive mineral resources, including large reserves of bituminous, anthracite and coking coal, along with deposits of iron ore, bauxite, mica, lead, molybdenum, gold and silver. These natural resources have provided the base for the growth of large scale industrial development led by engineering, nonferrous metallurgical, and textile industries, and Henan Province is a national leader in lead, aluminum, and glass production. Zhengzhou, the provincial capital, lies in the heart of the cotton-growing area and is one of the main focal points of China's textile industry.

*Nearby cities*

Xinxiang is located 37 miles to the south-west of Hebi and is the chief city of northern Henan. Situated at the junction of major east-west and north-south rail lines, Xinxiang is also linked by the highway network to the three large provincial cities of Zhengzhou, Kaifeng and Luoyang and via expressway to Beijing. In addition to cotton-textile production, spinning, and dyeing, its industries now include food processing and the manufacture of electronics, pharmaceuticals, machinery, automobiles and automotive parts, and chemicals. The city has grown rapidly to an urban population of 5.5 million.

Anyang, with a total population of 5.2 million, lies 25 miles to the north-west of Hebi. It has been a regional agriculture and trade center for centuries and is located on the main north-south rail line from Beijing to Guangzhou. Established textile mills and food-processing plants have been joined by heavy manufacturing and high-tech industries.

## 5.5 Guizhou

### 5.5.1 Regional Natural Gas Demand

As of early 2010, Guizhou is a virtually untapped gas market. The province has no known conventional oil or natural gas deposits. Despite Guizhou's proximity to the gasfields in neighboring Sichuan Province, the central government has chosen to allocate the output of these fields to more populated, developed provinces. As a result, no pipelines link Guizhou to Sichuan with the exception of a short, dedicated pipeline across the Yangtze River to an ammonia/urea fertilizer complex in the city of Chishui on the Sichuan border. This single facility accounts for the vast majority of the reported 500 million cubic meters of natural gas reported to have been consumed in Guizhou in 2007 (CESY, 2008 Table 5-22, Cnlist 2010).

Token amounts (perhaps 10-20 million cubic meters per year) of LNG from several small Chinese plants have been trucked into Guizhou since 2006 to serve only a small number of residential customers and automotive CNG users in various cities. With the commissioning of the Dazhou small-scale LNG plant in Sichuan in 2010, these shipments may increase on the order of 100 million cubic meters per year.

CMM is a major potential source of non-traditional natural gas for Guizhou. But at present, the vast majority of liberated CMM is lost as VAM. Of the 684 million cubic meters recovered in 2009 province-wide, all but 84 million were reported to be vented to the atmosphere (Xinhuanet Economic News 2010). No CMM is known to have been used outside of the immediate mining areas.

### 5.5.2 Future Demand and New Supply

Significant volumes of natural gas will enter Guizhou starting from approximately 2013 when the CNPC pipeline from Burma is scheduled to be completed. Guizhou political leaders have made a preliminary commitment to purchase up to three billion cubic meters of the pipeline's 12 billion annual flow by 2020 (Guizhou Capital City Newspaper, 2008). Initial volumes will undoubtedly be lower; between one and two billion cubic meters is a reasonable estimate.

The trunk pipeline will enter Guizhou from Yunnan Province to the west and run a reported 300 km eastward through Anshun Municipality, Guiyang, Duyun Municipality, Dushan and Libo Counties and onward to Guangxi Province. The Guizhou Gas Group has developed preliminary plans for a network of

branch pipelines from the trunk line, including a line that would run north from Guiyang towards the city of Zunyi.

A proposed 15 billion cubic meter per year pipeline from Ningxia Province in the north to the Guizhou capital city of Guiyang would open up Guizhou to significant quantities of gas from the northwest. The central government is unlikely to grant CNPC final permission to proceed with the line until it has secured a gas source, most likely from Turkmenistan through the so-called third West to East pipeline, currently in the planning and negotiation phase. Officials in Guizhou have expressed the hope that this pipeline could be completed at approximately the same time as the pipeline from Burma in 2013, but of securing the gas source could delay the project for several years (Sichuan News, 2010; International Gasnet, 2010).

Total demand is difficult to determine in the absence of supply, which itself tends to stimulate latent demand. Based on current estimated usages in Guizhou, natural gas substitution for other fuels would create demand in the vicinity of 1.5 billion cubic meters, as follows:

- About 1 billion cubic meters of natural gas to replace the estimated 2 billion cubic meters per year of coal gas currently burned as fuel in the province.
- 470 million cubic meters of natural gas to replace the estimated 400,000 tons per year of fuel oil currently consumed in the province.
- 175 million cubic meters of natural gas to replace the estimated 125,000 metric tons per year of liquefied petroleum gas (LPG) such as propane and butane currently consumed in the province (CESC, 2008 Tables 3-14, 3-15, 5-18; GSB, 2010 Table 5).

Residential consumption, which has been a major driver for natural gas development in many other locations, is likely to play a somewhat more modest role in Guizhou, with its small population and low urbanization level. If all of Guizhou's reported 11.4 million urban residents were to consume natural gas at the approximately 70 cubic meters per year per capita level of residential customers in Chongqing, total residential demand would be about 800 million cubic meters. Consumption at commercial facilities such as stores and restaurants would amount to an additional 100 million cubic meters, judging by the ratio of commercial to residential consumption in other parts of China.

Rapid development of industrial and other non-residential markets will therefore be necessary to absorb the considerable volume of new supply of natural gas likely to enter Guizhou starting from 2013. The significant number of heavy industry factories in Guizhou offer particularly promising potential markets. These, in addition to the industries that the CNPC is reported to be working with, include aircraft and other military equipment facilities, steel mills, cement plants, and phosphorous processing plants

Guizhou Gas Group will be partially responsible for the development of these markets. The CNPC itself, however, appears to be taking direct responsibility for the marketing of some of its Burmese gas in Guizhou.

Reports indicate that the CNPC plans to:

- Set up a network of 12 major CNG production sites and 120 to 150 CNG automotive filling stations throughout the province;
- Construct four combined cycle power generation stations to be used for peaking power;
- Develop residential distribution networks in a number of localities; and

- Create natural gas industrial parks, and sell directly to existing major industrial energy users such as the Guizhou Aluminum Factory and the Maotai Spirits Factory (Huaxia, 2010).

In summary, the size of the market in Guizhou is likely to exceed initial expectations once natural gas is actually present and the convenience and environmental benefits of natural gas are experienced for the first time. The speed at which this transformation occurs, however, is hard to predict, and there remains some possibility that the supply of new pipeline gas may temporarily exceed in-province demand.

### 5.5.3 CMM Market and End-Use Options

An in-province pipeline network has been planned to distribute Burmese gas. Additionally, the Guizhou Gas Company has contemplated a pipeline network that would extend to Renhuai County, approximately 30 km east of Linhua, but has not indicated how quickly this network will be constructed.

Prior to the anticipated arrival of gas from Burma in 2013, Guizhou should be able to absorb LNG produced by Linhua. Even if supply temporarily outstrips demand for the first few years after the arrival of pipeline gas, local distribution companies under the Guizhou Gas Group – and possibly even those under CNPC - will have an interest to retain a reliable local supplier like Linhua in order to:

- Hedge against the risks of supply interruption from Burma
- Supply the parts of the province that are not initially covered by the new pipeline network

The estimated city-gate Guizhou price of 2.8 to 3.0 RMB per meter for Burmese gas will establish the baseline for the ex-LNG plant price that Linhua would be able to charge a distribution company. Given the reported 0.1 RMB per 100 km tanker truck transport cost for LNG produced by other CBM producers in China and the approximately 300 km distance from Linhua to Guiyang, 2.5 RMB per cubic meter represents a reasonable estimate for the price that Linhua could expect to receive.

Locations outside of Guizhou may offer attractive markets for CMM. Shortages of gas in larger, more developed provinces such as Guangdong, or even Guangxi, are likely to remain acute even as supply of imported gas pipeline gas and LNG increases. The unserved or underserved medium-sized cities in these provinces offer particular possibilities.

Wholesale prices to Guangdong/Guangxi for imported LNG or pipeline gas from Central Asia and the Northwest will likely be 3.5-4.0 RMB rather than 3.0 RMB as in Guizhou. This would compensate for the higher transport costs to the markets in Guangdong and Guangxi, located 1,000 to 1,500 km distance from Linhua. Private natural gas distribution companies with franchises in these areas have indicated informally those prices as high as 3.0 RMB per cubic meter could be considered for LNG produced in the Chongqing – Guizhou area.

### 5.5.4 Pricing

The provincially owned Guizhou Gas Group is the predominant distribution company both for coal gas and for the limited volumes of pipeline natural gas currently distributed in the major cities of Guizhou such as Guiyang, Zunyi County. The prices it can charge its customers for both coal gas and natural gas are fixed by The Guizhou Provincial Price Bureau.

Due to their political sensitivity, prices to residential consumers are lower than costs in many locations. Nonetheless almost all distribution companies throughout the country operate with at least a small profit due to the willingness of the local regulators to allow significantly higher charges to industrial and commercial customers in order to ensure full cost recovery.

The difference between the wholesale prices paid by the distribution companies and the prices that they charge to residential customers typically fall in the 0.5-1.0 RMB per cubic meter range. The comparable mark-ups to industrial users can be as high as one to two RMB. Generally speaking, wholesale price increases are passed on to final consumers, sometimes with a time lag.

In view of the varying costs of the upstream gas source, retail prices vary widely by region. The range for prices to residential users near year-end 2010 is approximately as follows:

- 1 - 2 RMB per cubic meter in cities such as Chongqing, located near major gasfields;
- 2.5 - 3.0 RMB per cubic meter in heartland cities served by long-distance domestic pipelines;
- 3.5 - 4.0 RMB per cubic meter in cities dependent on LNG imported under long-term contracts;
- 4.5 – 6.0 RMB per cubic meter in certain cities in Guangdong and eastern provinces dependent on spot LNG purchases or LNG from the small domestic plants.

Natural gas prices to residential and commercial users in the city of Kaili, Guizhou, at a reported 3.18 RMB per cubic meter and 3.49 RMB per cubic meter respectively, fall roughly in the middle of this spectrum (Chemnet, 2009). After a round of increases in 2010, Guiyang pipeline coal gas distribution prices reached rough equivalence with the Kaili natural gas distribution prices on a heating value basis (Guizhou Price Bureau 2010.1, 2010.2). These prices will inevitably shape Guizhou price regulatory authority expectations for price of natural gas from new sources.

# 6. Comparison of Opportunities between Provinces

## 6.1 Access to Market

### 6.1.1 Anhui

In Anhui Province, the city of Huainan presents the best opportunity for CMM utilization. In 2008, the city purchased about 2 billion kWh of electricity from the national grid and also obtained power from a 1,800-MW coal-fired power plant within the city limits. In Huainan and Hefei there are a number of commercial and industrial plants that could utilize natural gas. Most of the 11 successful CMM projects in the province have been power generation and town gas projects.(**Table 40**).

**TABLE 40: ANHUI PROVINCE CMM PROJECTS**

| Name | Project Type | Mine Status | Project Status | Mining Group(s) |
|---|---|---|---|---|
| Huaibei Mining Group Company | Power Generation | Active (underground) | Operating | Huaibei Mining Group Company |
| Huaibei Mining Group Company | Town Gas | Active (underground) | Operating | Huaibei Mining Group Company |
| Huainan Mining Group - Pansan Mine | Power Generation | Active (underground) | Operating | Huainan Mining Group |
| Huainan Mining Group | Town Gas | Active (underground) | Operating | Huainan Mining Group |
| Huainan Mining Group | VAM as Primary Fuel for Power Generation | Active (underground) | In Development | Huainan Mining Group |
| Huainan Mining Group | Boiler Fuel | Active (underground) | Operating | Huainan Mining Group |
| Huainan Mining Group | Industrial Use | Unknown | Closed | Huainan Mining Group |
| Huainan Mining Group - Pansan Mine | Town Gas | Active (underground) | Operating | Huainan Mining Group |
| Huainan Mining Group - CHP 1 | Combined Heat and Power (CHP) | Active (underground) | Operating | Huainan Mining Group |
| Huainan Mining Group - CHP 2 | Combined Heat and Power (CHP) | Active (underground) | In Development | Huainan Mining Group |
| Wanbei Coal and Electricity Group | Power Generation | Active (underground) | Operating | Wanbei Coal and Electricity Group |

Source: GMI (2011)

### 6.1.2 Chongqing

Chongqing has one of the oldest and best-developed natural gas distribution infrastructures in China due to its proximity to the Sichuan gasfields. The Chongqing electrical distribution system is dominated by the Chongqing Power Company, a subsidiary of the Central China Grid Company which accounts for about 78 percent of total supply, with the remainder coming from small regional grids and self-owned power plants of industrial enterprises. While the Chongqing Power Company itself has modest peaking power generation capacity, generation and transmission/distribution are fundamentally separated under the power system reforms of 2002. Chongqing has a variety of successful CMM projects including VAM destruction, town gas, boiler fuel, power generation, and an LNG project underway (listed below as "Other") (**Table 41**).

**TABLE 41: CHONGQING CMM PROJECTS**

| Name | Project Type | Mine Status | Project Status | Mining Group(s) |
|---|---|---|---|---|
| Chongqing Nantong Mining LLC | Town Gas | Active (underground) | Operating | ?Chongqing Nantong Mining LLC |
| Chongqing Nantong Mining LLC | Boiler Fuel | Active (underground) | Operating | ?Chongqing Nantong Mining LLC |
| Datong | VAM Destruction | Active (underground) | In Development | Songzao Coal and Chongqing Electricity Company Ltd. |
| Songzao Coal and Electricity Company | VAM Destruction | Active (underground) | In Development | Songzao Coal and Chongqing Electricity Company Ltd. |
| Songzao Coal and Electricity Company | Other | Active (underground) | In Development | Songzao Coal and Electricity Company |
| Songzao Coal and Electricity Company - Power Gen Phase 1 | Power Generation | Active (underground) | Operating | Songzao Coal and Electricity Co. |
| Songzao Coal and Electricity Company - Power Gen Phase 2 | Power Generation | Active (underground) | In Development | Songzao Coal and Electricity Co. |
| Zhongliangshan Coal Electricity Gas Co | Boiler Fuel | Active (underground) | Operating | ? Zhongliangshan Coal Electricity Gas Co |

Source: GMI (2011)

### 6.1.3 Hebi

Hebi City receives natural gas via a trunkline from the West-to-East pipeline which supplies gas to northern Henan province, including the cities of Xinxiang, Anyang as well as Hebi. Hebi has a well developed gas distribution system.

Henan province is the sixth largest provincial consumer of electricity in China. Large electricity consumers include electricity-intensive industries such as magnesium producers, due to the region's extensive dolomite resources, and cement manufacturers, such as the Tongli Cement Company which used 170 million kWh in 2007. Henan province has a variety of CMM project types including VAM destruction, combined heat and power, and power generation. Hebi has two power generation projects as showed in **Table 42**.

**TABLE 42: HEBI AREA CMM PROJECTS**

| Name | Project Type | Mine Status | Project Status | Mining Group(s) |
|---|---|---|---|---|
| Hebi Coal Industry Group - Power Gen 1 | Power Generation | Active (underground) | Operating | Hebi Coal Industry Company |
| Hebi Coal Industry Group - Power Gen 2 | Power Generation | Active (underground) | Operating | Hebi Coal Industry Company |

Source: GMI (2011)

### 6.1.4 Guizhou

The Guizhou power grid is one of five interconnected provincial grids which are controlled by the state-owned China Southern Power Grid Company (CSPGC). Guizhou has become an important electricity supplier to nearby Guangdong and it is expected that Guangdong will continue to depend on significant volumes of electricity purchase from Guizhou and other CPSGC provinces for the foreseeable future.

Currently natural gas in Guizhou is limited to LNG trucked in and used for a small number of residential and automotive customers. Guizhou's pipeline network is expected to expand with the CNPC pipeline from Burma completing in 2013. The trunk pipeline will enter Guizhou from Yunnan Province to the west and run a reported 300 km eastward through Anshun Municipality, Guiyang, Duyun Municipality, Dushan and Libo Counties and onward to Guangxi Province. The Guizhou Gas Group has developed preliminary plans for a network of branch pipelines from the trunk line, including a line that would run north from Guiyang towards the city of Zunyi. These developments increase the viability of different kinds of CMM projects, as currently no CMM is known to have been used outside of the immediate mining areas. Guizhou has two CMM projects as shown in **Table 43**.

**TABLE 43: GUIZHOU CMM PROJECTS**

| Name | Project Type | Mine Status | Project Status | Mining Group(s) |
|---|---|---|---|---|
| Shuicheng Mining Group | Power Generation | Active (underground) | Operating | Shuicheng Mining Group |
| Shuicheng Mining Group | Town Gas | Active (underground) | Operating | Shuicheng Mining Group |

Source: GMI (2011)

## 6.2 Pricing

**TABLE 44: COMPARISON OF ELECTRICITY AND NATURAL GAS PRICES ACROSS PROVINCES**

| Province | Wholesale Electricity Price (RMB/kWh) | Natural Gas Price (RMB/cubic meter) | |
|---|---|---|---|
| Anhui | 0.345 (coal power with FGD) | CNPC Xinjiang gas, first West to East Pipeline Residential | 1.54 |
| | | CNPC Xinjiang gas, first West to East Pipeline Industrial | 1.965 |
| | | Sinopec Sichuan gas, Sichuan to East Pipeline (all uses) | 2.16 |
| Chongqing | 0.36 - 0.43 (coal power)<br>0.48 - 0.50 (natural gas fired power) | Industrial | 1.67 |
| | | Residential | 1.40 |
| | | Commercial | 2.21 |
| | | Automotive CNG (to gas station) | 1.17 |
| Hebi Area/Henan | 0.33-0.49<br>0.48 (natural gas fired power) | City-gate from the main first West to East CNPC trunkline - Industrial | 2.0 |
| | | City-gate from the main first West to East CNPC trunkline - Residential | 1.6 |
| Guizhou | 0.324 (power from local coal mines) | Cities located near major gasfields (retail) | 1-2 |
| | | Cities served by long-distance domestic pipelines (retail) | 2.5-3.0 |
| | | Cities dependent on LNG imported under long-term contracts (retail) | 3.5-4.0 |

In Anhui, the recent average wholesale electricity price is 0.345 RMB/kWh; however, mines such as the Liuzhuang mine may pay as high as 0.85 RMB/kWh peak-period power rates, and during more typical conditions, 0.57 RMB/kWh. These rates make mine site power projects look attractive in Anhui. Regarding natural gas prices, the city-gate price paid in Anhui from the West-to-East Pipeline is similar to retail prices paid by automotive CNG users in Chongqing and similar long-distance pipeline customers in Guizhou.

Chongqing benefits from low priced hydro power with wholesale prices between 0.2 and 0.3 RMB per kWh, significantly lower than the 0.48-0.50 RMB per kWh obtained for gas fired power. Chongqing's

regulated natural gas prices are some of the lowest in China in because of its proximity to the gas source and because of its long history of gas use.

Hebi area electricity prices and natural gas prices are both similar to Chongqing, although commercial customers in Hebi pay a high 0.73-0.80 RMB per kWh. The Hebi region benefits from its relative proximity to gas supplies from the Ordos Basin and as such, natural gas prices are lower than on the east coast.

Guizhou coal fired power wholesale prices are slightly lower than other provinces. Guizhou's electric power is expected to remain strongly cost competitive in view of the availability in Guizhou of inexpensive local coal and water resources. Guizhou is a largely untapped gas market, thus gas prices are based mostly on pipeline and LNG prices. Cities served by long-distance pipelines are paying a high 2.5-3.0 RMB/cubic meter.

# 7. Conclusion

## 7.1 Summary of National Issues Impeding the CMM Market

Though China's government has implemented a number of policies and mechanisms to encourage natural gas CMM development with some success, there are a number of barriers to a widespread and flourishing CMM market. China's abundant low-quality drained CMM is not only unsafe to use, but safely transporting and handling explosive gas mixtures is unreliable. Additionally, inconsistent laws, such as that requiring use of CMM with methane concentration greater than 30 percent affects additionality of a number of high quality CMM recovery and utilization CDM projects.

Coal provides 69 percent of the energy consumed annually in China, with only four percent provided by natural gas. Being considerably cheaper to produce than natural gas, coal will remain the dominant power source into the future. Currently, with China's underdeveloped natural gas market, many do not have access to natural gas, limiting the potential market for CMM. Of the estimated 577 million people living in Chinese cities, suburbs, and towns, only 102 million had access to natural gas at year-end 2005. Entire provinces, such as Guizhou, Yunnan, Guangxi, Jiangxi, and Fujian offered virtually no gas to their urban residents, and even highly-developed provinces such as Guangdong and Jiangsu only offered gas to 18 and 6.6 percent of their respective city and town dwellers.

Given the rapid construction of electricity generation capacity in China since 2003, including many projects still outstanding, there is a distinct possibility that power generation capacity will outstrip demand in many parts of the country over the next three to five years. The appetite for new power construction will likely decrease correspondingly, and dispatch of existing plants – particularly coal-fired power plants – will decrease.

## 7.2 Summary: Provincial Issues Impeding the CMM Market

In Anhui, many mines are located in rural areas lacking a natural gas market. At the Liuzhuang mine, for example, nearby villages utilize either agricultural waste (straw) or waste coal for heating. Waste coal is abundant and quite inexpensive. CMM in areas such as this would need to be sold at an extremely low price to displace this waste coal.

Chongqing has a well developed gas infrastructure; however gas prices are among China's lowest. Chongqing Gas may not prove to be a reliable long-term customer absent administrative direction from the municipal government and/or a major increase in the cost of gas to Chongqing from the domestic producers. This means CMM recovered in Chongqing will most likely need to be sold outside of the province, such as to neighboring provinces like Guangxi and Guizhou.

Chongqing is one of six provincial level units making up the Central China grid. The Central China grid is a net power exporter to the rest of China, with generation exceeding supply within the grid by about 60,000 GWh in 2007. The surplus comes from the rich hydropower resources in the region (hydro accounted for about one third of the Central China grid's output in 2006, far and away the highest such percentage in the country). The abundance of hydropower in the region makes CMM generated power less attractive.

Hebi is supplied with high-quality natural gas from a trunkline of the West-to-East pipeline. CMM in the region would likely require extensive processing to reach the quality of the gas already used in Hebi, and building transmission lines would be necessary to get gas to urban markets. Although national policies encourage sales of CMM-generated electricity to the grid, policies are not widely enforced and local electric grid operators have ignored them in the past. Power generation for onsite use at mines is already done at some mines in the region, such as Hebi Mine No. 6. Hebi has low winter temperatures (-2 degrees C in January) thus heat produced during power generation could be used to heat mine air.

Guizhou is a virtually untapped gas market with limited infrastructure. Token amounts of LNG from several small Chinese plants have been trucked into Guizhou since 2006 to serve only a small number of residential customers and automotive CNG users in various cities, although developments of LNG plants in Sichuan may increase this service. CMM is a major potential source of non-traditional natural gas for Guizhou. But at present, the vast majority of liberated CMM is lost as VAM. Increased drainage will be required in order for CMM to provide significant natural gas to Guizhou. Sales outside of Guizhou are an option as shortages of gas in larger, more developed provinces such as Guangdong, or even Guangxi are likely to remain acute even as supply of imported gas pipeline gas and LNG increases.

Guizhou's disproportionate economic dependence on energy-intensive extraction and manufacture of commodities such as coal, chemical fertilizers and their inputs/associated products, and aluminum, creates the potential for some volatility in electricity demand. In addition, The Guizhou regulatory authorities have not yet taken concrete measures to enforce NDRC requirements[6]. Virtually all power generated by Guizhou CMM plants, therefore, is being distributed through the mining companies' grids for their own consumption. Some mining companies with the capability to generate excess power have been forced to idle capacity due to their inability to reach interconnection and sales agreements.

## 7.3 Benefits to Implementing CMM Projects in China

There are multiple benefits to developing CMM projects in China. CMM projects reduce greenhouse gas emissions, improve mine safety, create jobs, improve local and regional air quality, and provide energy independence – of particular importance as China's energy needs are expected to double from 2005 to 2030 (IEA, 2009.1). China has the world's highest CMM emissions, with over 40 percent of the world's total in 2005 (IEA, 2009.1). With a booming coal market and government policies to encourage natural gas and CMM development, CMM projects are expected to continue to be favored. China is home to nearly all CMM projects registered as CDM projects – an important source of project funding.

[6] NDRC April 2007 *Opinions Regarding Use of Coalbed Methane and Coalmine* Methane: public grid companies purchase all power generated in excess of mining companies' own needs by CMM generation plants, pay the purchase price in a "timely manner," and pay the CMM power generators the same prices as for power from biomass generation plants, equivalent to the regulated wholesale purchase prices for power from new coal-fired plants, plus a 0.25 RMB per kwh surcharge.

### 7.3.1 Success Stories

The Huainan and Huaibei mining groups have had success with numerous projects in Anhui Province, with seven of the province's eight operating CMM projects. These projects, including power generation, town gas, boiler fuel, and combined heat and power, have all been developed as CDM projects. Five projects are registered as CDM projects while an three are in the validation process (UNEP, 2011). Annual greenhouse gas reductions estimated from all eight projects totals 2,059,584 tCO2e (561,678 metric tonnes of C equivalent, as reported in GMI database, GMI (2011)). Anhui has three registered CDM projects: Huaibei Haizi and Luling Coal Mine Methane Utilization Project, Anhui Huaibei Taoyuan Coal Mine Methane Utilization Project, and Anhui Huaibei Qinan Coal Mine Methane Utilization Project.

Chongqing has four operating CMM projects (GMI, 2011); three projects are registered CDM projects: Zhongliangshan Coal Mine Methane Project, Nantong Coalmine Methane, and Tianfu Coalmine Methane Project, and the Chongqing Datong Coal Mine VAM Destruction and Utilization Project has requested registration. The Datong coal mine project is expected to reduce greenhouse gas emissions by up to 200,000 tons of CO2e per year (CMOP, 2010). Chongqing is also home to the world's largest CMM purification and liquefaction project underway as of 2010 (see Box).

## USEPA CMM Feasibility Study to Result in World's Largest CMM Purification and Liquefaction Project

Chongqing Energy Investment Group (CQEIG), a state-owned enterprise in Chongqing municipality, China has selected Towngas, a listed company in Hong Kong, as a joint venture partner to implement the world's largest coal mine methane purification and liquefaction project. The project will be developed at the mines of CQEIG's majority-owned subsidiary, the Songzao Coal and Electricity Company. The project is based on the "Feasibility Study of CMM Utilization for Songzao Coal and Electricity Company Coal Mines," funded by US EPA and carried out by Raven Ridge Resources, Incorporated.

The project will gather, purify, and liquefy as many as 130 million cubic meters (pure methane) annually of medium-purity CMM from Songzao's six operating coal mines in Chongqing Municipality, southwest China. The resultant LNG will be transported by truck for consumption both locally and in booming natural gas consumption centers to the south and east.

The owners are considering the addition of a second plant with 40 million cubic meters annual capacity to purify and liquefy increased methane production from these mines in later years. The project also includes the construction of 26.9 MW of internal combustion engine power stations at new Songzao mines which will burn an additional 38 million cubic meters per year of CMM that cannot be economically transported to the LNG plant.

The project, first presented to the international community at the 2007 M2M Partnership Expo in Beijing, represents the fruits of a feasibility study undertaken in 2008-2009 with the support of the USEPA under the M2M program. The owners anticipate that the project will come online in 2012, and will generate approximately 44 million tons CO2e emissions reductions over its 15-year life.

CQEIG went through internal research, expert evaluation, analysis and comparison and selected Towngas as an equal partner in the project. Towngas has had practical experience in coal mine methane purification and liquefaction with oxygen removal. The two parties signed a joint venture agreement in December of 2009.

Total investment is expected to be 530 million RMB ($77.9 million USD). Agreements for land required for the project have been negotiated and the project is expected to start construction by the end of June. Phase I is expected to be completed at the end of 2011. After completion of all phases, the project will purify and liquefy 110 million cubic meters of coal mine methane. Annual sales of liquefied natural gas will reach 275 million RMB ($40.4 million USD).

Henan has nine operating CMM projects and the Hebi area has two. Henan is home to one registered CDM project, Jiaozuo Coal Mine Methane (CMM) Power Generation Project of Jiaozuo Coal Industrial Group Co. Ltd., Jiaozuo City, Henan Province.

Guizhou has two operating CMM projects and several in development. Two CMM projects from Guizhou are at the validation stage as CDM projects.

China is host to over 40 CMM projects registered as CDM projects and 64 total operating CMM projects. The largest CMM power project in the world is at the Sihe Mine in Jincheng, Shanxi Province. This project uses Caterpillar engines to generate electricity at a 120-MW capacity power plant. The project utilizes 180 million cubic meters of both CBM and CMM from the Sihe mine (USEPA, 2006.1; Huang, 2008). The Sihe project avoids the release of 2.5 million tonnes of carbon dioxide equivalent (MmtCO2e).

China is host to the first VAM project approved by the UNFCCC as a CDM project. The VAM abatement and energy recovery project was commissioned in October of 2008 in Zhengzhou and provides hot water for local use. Annual emission reductions average 382 thousand tonnes of carbon dioxide equivalent (MtCO2e) (UNFCCC, 2008).

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